Dual Use Study of Systems and Software Technologies:

Defence and IST Analysis Report

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Abstract

This report outlines an unbiased process to assess and prioritize information Technologies (IT), which can be identified as areas of high priority for defense R&D. The proposed process minimizes potential political and industrial biases and allows for the formation of a detailed list of Information Technologies, thus prioritizing and highlighting the IT areas that require attention and R&D funding. The Information Technologies ranking method process consists of a two-stage qualitative and quantitative analysis. This two-stage approach introduces strategic and system cost weighting factors to generate a ranked list of the areas of Information Technologies, which is derived from the defence procurement plans of the US and Canadian Forces. This ranking process allows also for the identification of the Dual Use Technologies (i.e. Dual Use Study of Systems and Software Technologies (DUST)) into five main areas, namely:

- Software and System Engineering;
- Information Management;
- Visualization and Imaging;
- Modelling and Simulation;
- IT aspects in Communication;

In summary, the proposed study may be considered as a strategic 'model' for considering review of Dual-Use Technologies and their associated R&D cost across different market sectors and system applications. In particular, this study is designed to improve the co-ordination, planning and exploitation of dual-use Information Society Technologies (IST), with a view to strengthening Canadian industrial competitiveness in defence as well as civil Information & Communication Technologies (ICT) industry.

Résumé

Ce rapport décrit un processus impartial servant à effectuer l'évaluation et à établir les priorités des technologies de l'information (TI), qui peuvent être considérées comme des secteurs de haute priorité en matière de R & D pour la défense. Le processus proposé réduit les risques possibles de partialité politique et industrielle et permet de constituer une liste détaillée de technologies de l'information, qui établit leurs priorités et met en évidence les secteurs de TI qui devraient faire l'objet d'attention et de financement en R & D. La méthode de classement des technologies de l'information se fonde sur une analyse qualitative et quantitative en deux étapes. Cette méthode tient compte de facteurs de pondération liés à la stratégie et au coût des systèmes pour dresser une liste ordonnée des secteurs de technologie de l'information, tirée des plans d'acquisition pour la défense des Forces des États-Unis et du Canada. Ce processus de classement permet aussi l'identification des technologies à double usage (Examen de la possibilité de double usage des technologies logicielles et des systèmes (EDUT)) faisant partie de cinq grands secteurs, soit :

- ingénierie des logiciels et des systèmes;
- gestion de l'information;
- visualisation et imagerie;
- modélisation et simulation; et
- aspects des TI dans les communications.

En résumé, on peut considérer que l'étude proposée offre un « modèle » stratégique permettant d'examiner les technologies à double usage et leur coût de R & D pour différents secteurs du marché et applications des systèmes. Plus précisément, cette étude vise à améliorer la coordination, la planification et l'exploitation des technologies de la société de l'information (TSI) à double usage, dans le but de renforcer la concurrence industrielle canadienne dans les secteurs de la défense ainsi que dans les secteurs civils des technologies de l'information et des communications (TIC).

Executive summary

The aim of the present analysis is to assess the potential Dual Use of Information & Communication Technologies (ICT) for the Defence and Civilian sectors of Information Technologies (IT). The proposed analysis minimizes potential political and industrial biases and allows for the formation of a detailed list of Information Technologies, thus prioritizing and highlighting the IT areas that require attention and R&D funding. The Information Technologies ranking method process consists of a two-stage qualitative and quantitative analysis. This two-stage approach introduces strategic and system cost weighting factors to generate a ranked list of the areas of IT, which is derived from the defence procurement plans of the US and Canadian Forces. This ranking process allows also for the identification of the Dual Use Technologies (i.e. Dual Use Study of Systems and Software Technologies (DUST)) into five main areas, namely:

- Software and System Engineering;
- Information Management;
- Visualization and Imaging;
- Modelling and Simulation;
- IT aspects in Communication;

The report consists of four major parts or sections.

- The first section summarizes briefly the two-stage qualitative and quantitative analysis that provides prioritization of the dual use technologies.
- The second section provides an analysis of the strategic priority factors relevant with the defence systems.
- The third section outlines the theoretical basis of the interrelations between the defence and civilian use systems, and finally,
- The forth part consists of the Annexes and includes the implementation results of the "Methodology" of the DUST project by having as input the 3-year procurement programs of the US and the Canadian Forces.

The results of the present analysis also form DRDC's deliverables for the international collaborative project DUST that receives funding from the European Commission (EC-IST, 2001-34118 DUST-project). Members of the DUST project consortium are the Defence Agencies of Canada (DRDC), Netherlands (TNO), UK (Quinetic) and Denmark (DDRE). Thus, it is anticipated that the present analysis would contribute to future Information Society Technologies (IST) thematic prioritization and program development. In summary, this study is designed to improve the co-ordination, planning and exploitation of dual-use Information

Society Technologies (IST), with a view to strengthening the Canadian industrial competitiveness in defence as well as civil Information & Communication Technology (ICT) sectors.

Wong, W., Stergiopoulos, S., Reid, R., Bhartia, P. 2002. Dual Use Study of Systems and Software Technologies: Defence and IST Analysis Report. DRDC Toronto TR 2002-188. DRDC Toronto.

Sommaire

Cette analyse a pour objet d'évaluer la possibilité de double usage des technologies de l'information et des communications (TIC) dans les secteurs civil et de la défense des technologies de l'information (TI). L'analyse proposée réduit les risques possibles de partialité politique et industrielle et permet de constituer une liste détaillée de technologies de l'information, qui établit leurs priorités et met en évidence les secteurs de TI qui devraient faire l'objet d'attention et de financement en R & D. La méthode de classement des technologies de l'information se fonde sur une analyse qualitative et quantitative en deux étapes. Cette méthode tient compte de facteurs de pondération liés à la stratégie et au coût des systèmes pour dresser une liste ordonnée des secteurs de TI, tirée des plans d'acquisition pour la défense des Forces des États-Unis et du Canada. Ce processus de classement permet aussi l'identification des technologies à double usage (Examen de la possibilité de double usage des technologies logicielles et des systèmes (EDUT)) faisant partie de cinq grands secteurs, soit :

- ingénierie des logiciels et des systèmes;
- gestion de l'information;
- visualisation et imagerie;
- modélisation et simulation; et
- aspects des TI dans les communications.

Le rapport se compose de quatre grandes parties ou sections.

- La première section résume brièvement l'analyse qualitative et quantitative en deux étapes qui établit les priorités des technologies à double usage.
- La deuxième section fournit une analyse des facteurs de priorité stratégique applicables aux systèmes de défense.
- La troisième section décrit les fondements théoriques des interrelations entre les systèmes de défense et civils.
- Enfin, la quatrième partie regroupe les annexes et présente les résultats de mise en œuvre de la méthodologie du projet EDUT à partir des programmes d'acquisition pour 3 ans des Forces des États-Unis et du Canada.

Les résultats de cette analyse forment aussi les produits livrables de RDDC dans le cadre du projet EDUT de collaboration internationale, qui bénéficie de financement de la Commission de l'Union européenne (TSI CU, projet EDUT 2001-34118). Les membres du consortium du projet EDUT sont les Agences de défense du Canada (RDDC), les Pays-Bas (TNO), le Royaume-Uni (Quinetic) et le Danemark (DDRE). Il est donc à prévoir que cette analyse contribuera à l'établissement des priorités thématiques et à l'élaboration des programmes

touchant les futures technologies de la société de l'information (TSI). En résumé, cette étude vise à améliorer la coordination, la planification et l'exploitation des technologies de la société de l'information (TSI) à double usage, dans le but de renforcer la concurrence industrielle canadienne dans les secteurs de la défense ainsi que dans les secteurs civils des technologies de l'information et des communications (TIC).

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Methodology: A two stage qualitative - quantitative analysis

The concern as to which kind of Information Technologies (IT) should be identified as areas of high priority for research and development (R&D), and consequently for funding, is an integral part of the vision associated with the technological achievements that a Society or a Country wishes to pursue. However, the process of forming a list of Information Technologies that should be considered as areas of high-priority for R&D funding is frequently either politically biased or it receives severe criticism because of industrial bias arising from specific industrial interests. In both cases, the bias would seriously affect the long-term R&D activities and distort the vision that generated the R&D efforts.

The aim of this analysis is to introduce a process that minimizes this kind of bias and allows the formation of a detailed list of Information Technologies, thus prioritizing the IT areas that require attention and R&D funding. The proposed process considers the following assumption, which is also graphically illustrated in Figure 1:

Defence Systems include the majority of advanced Information Technologies that are being integrated in civilian use system development activities with a time lag factor of a few years.

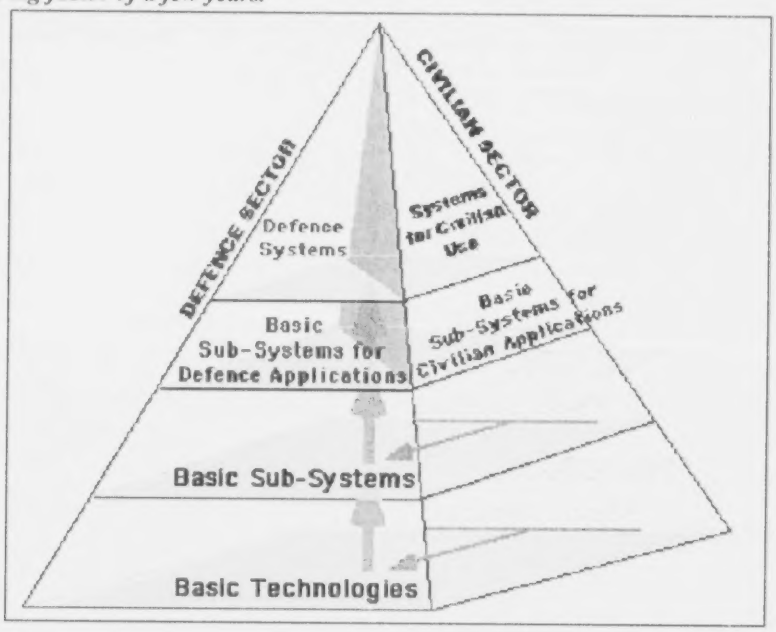

Figure 1. Dual Use Technology Structure

This assumption is very critical for our analysis because the Ministries of Defence of USA, Canada and the EU Member States periodically generate detailed five-year procurement plans for defence systems. Each defence system procurement plan includes the two main weighting factors of 1) the defence priority and 2) the cost of the proposed defence system.

The defence procurement plans are not classified and are being published in the open literature of defence journals such as "Jane's Defence". Thus, these plans can provide well-documented lists of systems with their associated strategic importance and their financial costs. In other words, the defence systems can be a source of information to document the associated dual-use information technologies for both defence and civilian use.

The analysis that follows is an inverse process that decomposes the defence systems in generic dual-use sub-systems and their associated technologies. It includes a two stage qualitative and quantitative analysis to derive the weighting factors that would assist in the prioritization of Information Technologies. Since the analysis is based on the list of defence systems that are included in the five-year procurement plans for defence systems of the EU Member States, acceptability of this analysis is subject to the validity of the assumption stated above.

Qualitative analysis

Figure 2 shows a simple decomposition model for a major system. The lower part of this figure shows a simplified analysis of a system into sub-systems. In this case, it is clearly shown that a generic sub-system can be a component in more than two systems. In other words, this kind of multiple use process generates a cumulative factor that would enhance the importance of a specific list of generic sub-systems. To provide a system realization of this generic decomposition model, consider the example of a *sonar defence system* that includes the two generic sub-systems of:

- *a signal processor* with the signal processing functionality of the sensor time series that allows for detection and parameter estimation of signals of interest; and
- *a display unit* that provides a tactical picture and visualization of processed information for target localization and classification.

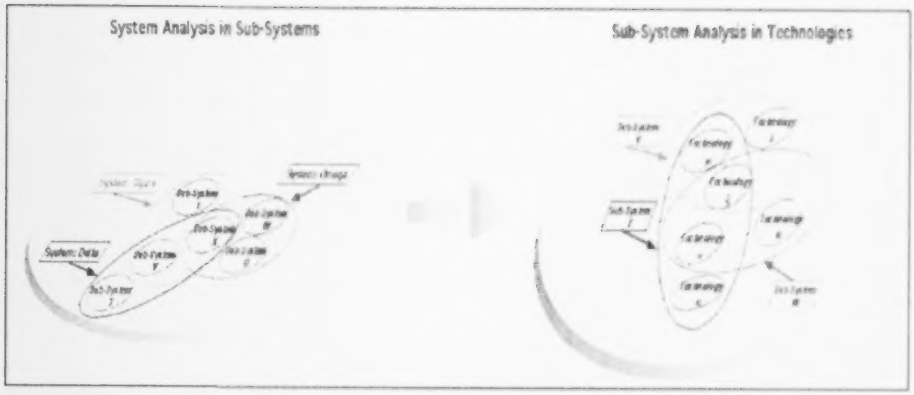

Figure 2. *Generic Decomposition Model for Major Systems*

The above generic sub-systems are also included in various types of naval, airborne and ground-based radar systems, various types of missiles, command & control and defence surveillance systems. The same kind of generic sub-systems can also be applied to civilian use systems such as, medical ultrasound diagnostic imaging systems, sonars for civilian use, radars for air-traffic control, medical imaging (i.e. MRI, CT/X-ray) systems. Therefore, the sub-systems of this example can be characterized as dual-use generic sub-systems.

Next, the upper part of Figure 1 provides an interrelationship between a generic sub-system and the associated group of Information Technologies that are required to develop the generic sub-system of interest. Since an Information Technology can be used in the development process of more that two sub-systems, as this is illustrated in Figure 2, this kind of interrelationship generates another cumulative factor that enhances the importance of a specific list of Information Technologies. As a follow up of the previous example, the dual-use Information Technologies associated with the generic sub-systems discussed above are:

- Computing architecture associated with signal processor and display unit sub-systems
- Array signal processing of received sensor time series associated with the signal processor sub-system, and
- Signal tracking, target localization, neural networks, data fusion, visualization and image processing associated with the display unit sub-system.

The above simplified decomposition model is the first stage of analysis of the proposed process. Moreover, this model is valid for both the defence and civilian use systems.

Our next step is to examine the integration process of dual-use technologies that leads to generic dual-use sub-systems. Figure 1 illustrates a simplified overview of the interrelations between the defence and civilian use systems. These interrelations are integral parts of a very robust R&D-industrial structure of the Western World Countries (North America & Western Europe). This structure is considered in this analysis to be a pyramid. The degree of stability

and robustness of this structure provides a measure of the economical & technological prosperity and defence superiority of the Western World Countries with respect to the rest of the world.

Let us analyze now the basic components of the pyramid-structure. As shown in Figure 1, the basis of the structure is defined by dual-use technologies, such as those discussed above. Application of the dual-use technologies leads to the next level of the structure consisting of dual use basic sub-systems. The next stage of evolution of the R&D-industrial structure leads to two autonomous sections that form the upper part of the pyramid-structure. The left hand side section is the "Defence Sector" and the right hand side is the "Civilian Sector". Each of the two sectors includes the basic sub-systems that are used to develop complete defence and civilian use systems, respectively.

Quantitative analysis

The major advantage in considering the defence systems in this analysis is that the five-year procurement plans of the USA, Canada and the EU Member States provide well documented lists of defence systems with their defence priorities and financial cost estimates. Then, for each system the associated defence priority and financial cost can be used as weighting coefficients to assess the priority of the defence systems.

Therefore, the two weighting coefficients (defence priority and financial cost) and the qualitative analysis outlined above, form the basis of our quantitative analysis in assessing the dual-use Information Technologies.

Briefly, the proposed quantitative analysis consists of the following processing steps that are schematically illustrated in Figure 3.

Step#1: Collect the five-year procurement plans of each EU Member State. This information can be available directly from the relevant Ministries of Defence or from Reference: Jane's Defence

Step#2: Form a table, under the title "Process of Assessment". The table should include lists of:

- The defence systems from the 5-year procurement plans;
- The defence priority weighting factor associated with each defence system;
- The financial cost weighting factor associated with each defence system; and
- The derived defence system's priority factor based on the combined weighting factors (i.e. defence priority, system cost).

Note: It is assumed in this process that the weighting factors of defence priority and system cost have been normalized with respect to the total number of systems considered in the 5-year procurement plan.

Step#3: Defence Industries provide technical information and analyze the defence systems into sub-systems and associated technologies, according to the model shown in Figure 2.

Step#4: Form a table under the title "(Defence Systems) - (Sub-Systems) x (Priority Factor) = (Cumulative Process)". The table should include lists of:

- The defence systems from the 5-year procurement plans;
- The sub-systems associated with each defence system;
- The combined priority factors associated with each defence system. The combined priority factors are provided from Step#2; and
- The derived combined priority factors for each sub-system. This kind of combined priority factors are the result of a cumulative process discussed in the previous Qualitative Analysis sub-section and shown schematically in Figure 3.

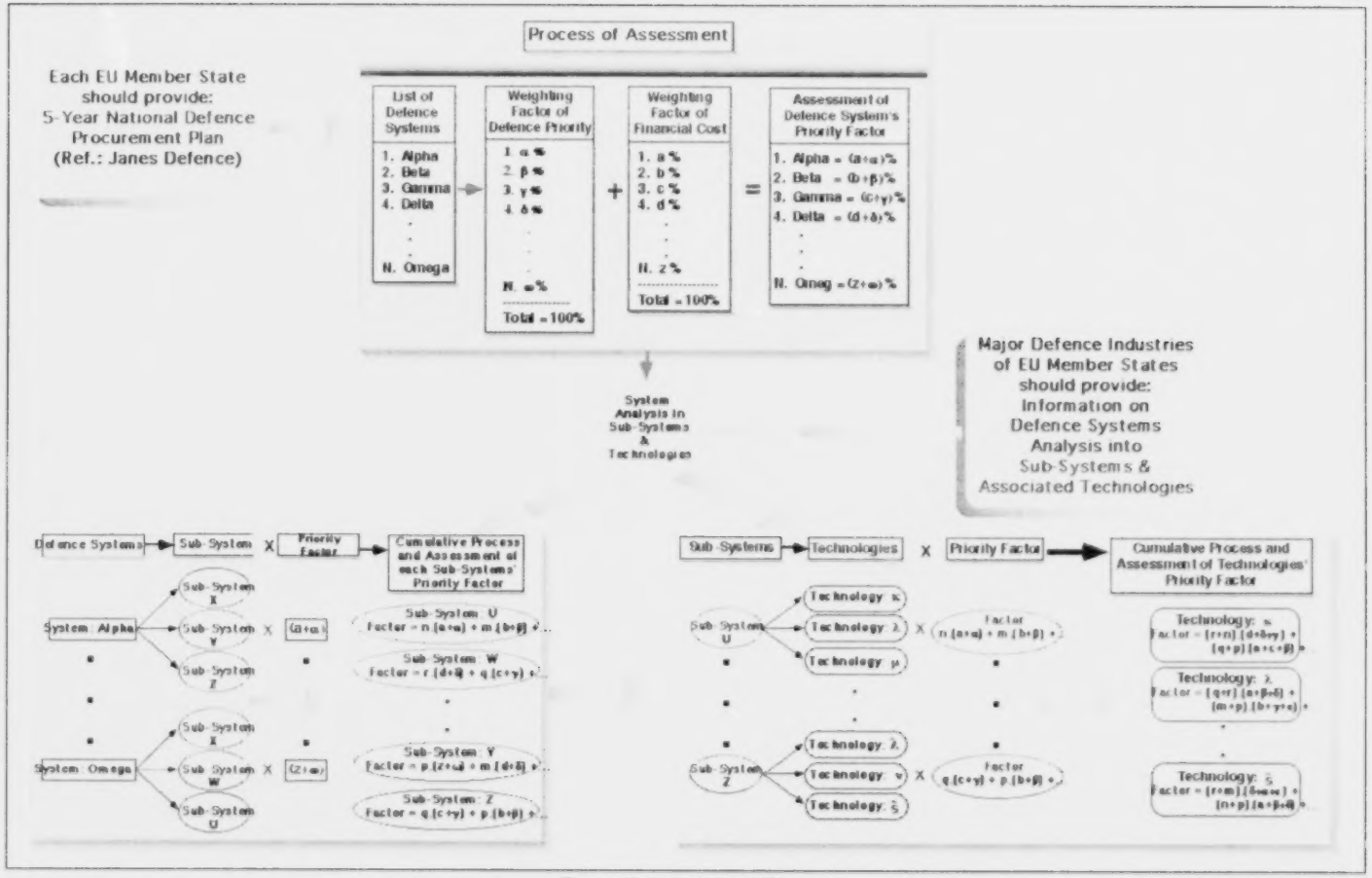
Process of Assessment
Each EU Member State should provide: 5-Year National Defence Procurement Plan (Ref.: Janes Defence)
List of Defence Systems
Weighting Factor of Defence Priority
Weighting Factor of Financial Cost
Assessment of Defence System's Priority Factor
1. Alpha
2. Beta
3. Gamma
4. Delta
N. Omega
Total = 100%
System Analysis in Sub-Systems & Technologies
Major Defence Industries of EU Member States should provide: Information on Defence Systems Analysis into Sub-Systems & Associated Technologies
Defence Systems
Sub-System
Priority Factor
Cumulative Process and Assessment of each Sub-Systems' Priority Factor
System: Alpha
System: Omega
Sub-Systems
Technologies
Cumulative Process and Assessment of Technologies' Priority Factor

Figure 3. Assessment Process

Step#5: Form a table under the title "(Sub-Systems) - (Technologies) x (Priority Factor) = (Cumulative Process)". The table should include lists of:

- The sub-systems provided from the output of Step#4;
- The Technologies associated with each sub-system. This list of technologies are the output results of Step#3;
- The combined priority factors associated with each sub-system as derived from Step#4; and
- The derived combined priority factors for each Technology. These kind of combined priority factors are the result of a cumulative process discussed previously.

The output results of Step#5 provide an assessment and prioritization of the dual-use Information Technologies. The critical factor in this process is the information that would be provided by the Defence Industries in Step#3.

Implementation

For the present analysis, implementation of the proposed two-stage methodology was based on the procurement programs of the DoD of USA and DND of Canada. Table 4, page 12 provides a list of all the procurement projects of the DoD/USA listed in Jane's Defence. To compile our database, the 18 U.S. DoD Capital Projects shown below in Table 1 were selected from the different military categories.

Table 1. *DoD Capital Programs*

AIRCRAFT
AH-64D Longbow Apache
EA-6B Prowler
E-2C Hawkeye
F/A-18E/F Super Hornet
Stealth B-2A
E-8C Joint Star
UAV
MUNITIONS
ATACMS (Army Tactical Missile System)
TOMAHAWK
AMRAAM Advanced Medium Range Air-to-air Missile
NAVY VESSELS
DDG-51 AEGIS Destroyer
NSSN Virginia Class Submarine
ARMY COMBAT VEHICLES
M1A2 Abrams Tank Upgrade
SPACE PROGRAMS
DSCS (Defense Satellite Communications System)
NAVSTAR Global Positioning System
OTHER PROGRAMS
SFW (Sensor Fuzed Weapon)
ABL Airborne Laser
National Missile Defense (NMD)

The breakdown of each program into subsystems and technologies was derived from Jane's Defence database to establish a common reference for interpretation. Based on the inputs defined in Table 2, the implementation results of the proposed DUST methodology are presented analytically in Annexes A through I. Annex information can be interpreted by using the explanatory remarks of the following sub-sections.

Table 2. *Summary of Implementation Results of DUST Methodology*

DUST AREA	NORMALIZED COMBINED COST OF DUST AREA	NORMALIZED COMBINED PRIORITY OF DUST AREA	NORMALIZED COMBINED COST*PRIORITY OF DUST AREA
Software and System Engineering	1.0000	0.9707	0.975898
Information Management	0.9979	1.0000	1.000000
Visualization and Imaging	0.4068	0.4002	0.382174
Modeling and Simulation	0.8274	0.8926	0.80008
IT in Communication	0.6020	0.6373	0.600909

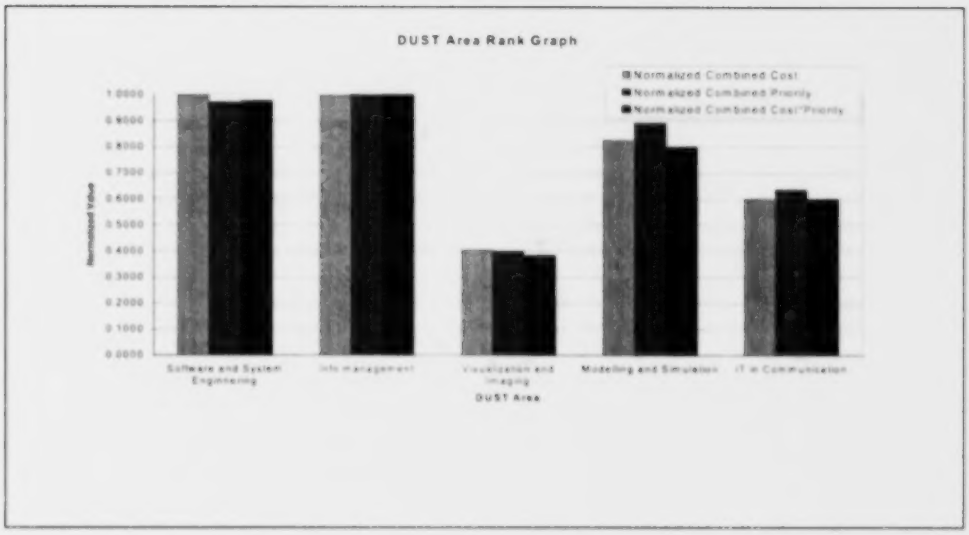

Figure 4. *DUST Area Rank Graph*

Descriptions of annex data sheets and graphs

The information gathering process is the preliminary step of the DUST Analysis. Extensive research on each of the selected DoD programs is performed on the Jane's Defence Information Group (**www.Jane's.com**) [43]. The research identifies all major components of the specific defence program from which decisions are made regarding what systems and software technologies are being used in the components. In this stage, the individual technologies are also classified into more general categories. For example, individual technologies such as processor data link and digital computer will all be listed under the broader category of Computer Architecture.

Also, three-year (FY2001, FY2002 and FY2003) total acquisition costs (in millions) of each program were listed [44]. The resulting charts and data sheets of this initial research are described below.

Program Cost Factor (Annex A)

In this data sheet, the total of all the selected defence program are calculated and then the cost of each individual program is listed as a percentage of the total cost. The cost factor is integrated into the *Program Combined Analysis* datasheet.

Program Rank Summary (Annex B)

A summary of percentage cost factor, normalized priority factor, Cost Factor*Priority Factor and the normalized Cost Factor*Priority Factor for each selected program can be found in this data sheet.

Program Priority Factor (Annex C)

In this data sheet, the selected defence programs are rated on a scale of 1 to 10 for each relative priority such as Strategic Deterrence and Countering WMD. The relative priority categories are derived from the characteristics of a Full Spectrum Force as suggested in [45]. The cumulative rating of the each program is then expressed as a normalized priority factor that would be integrated into the *Program Combined Analysis* datasheet.

Program Cost and Priority Graph (Annex D)

The results of the Program Rank Summary data sheet are presented here in a bar chart that allows user to see the relative priority and percentage of defence spending in a graphic way.

DUST Area Rank Summary (Annex E)

As illustrated in the *Program Combined Analysis* data sheet and Table 2, each of the technologies is classified and colour-coded according to [46] into five main areas, namely:

Software and System Engineering,

Info management,

Visualization and Imaging,

Modelling and Simulation,

IT in Communication.

In this data sheet, as suggested by the column heading, the cost factors of each individual technology listed under the same DUST Area are being added up and compared to total cost factor of the other DUST Area's. The sum of the priority factor, and the cost*priority factor are compiled the same way.

DUST Area Rank Graph (Annex F)

The results of the DUST Area Rank Summary data sheet are presented here in a bar chart as in Figure 4 that allows user to compare the relative cost and priority of each DUST Area in a graphic way.

Technology Rank Graph (Annex G)

. The results of the Technology Rank Summary data sheet are presented here in a bar chart that allows user to compare the relative cost and priority of each category in a graphic way. This Technology Rank Graph is illustrated in Figure 5.

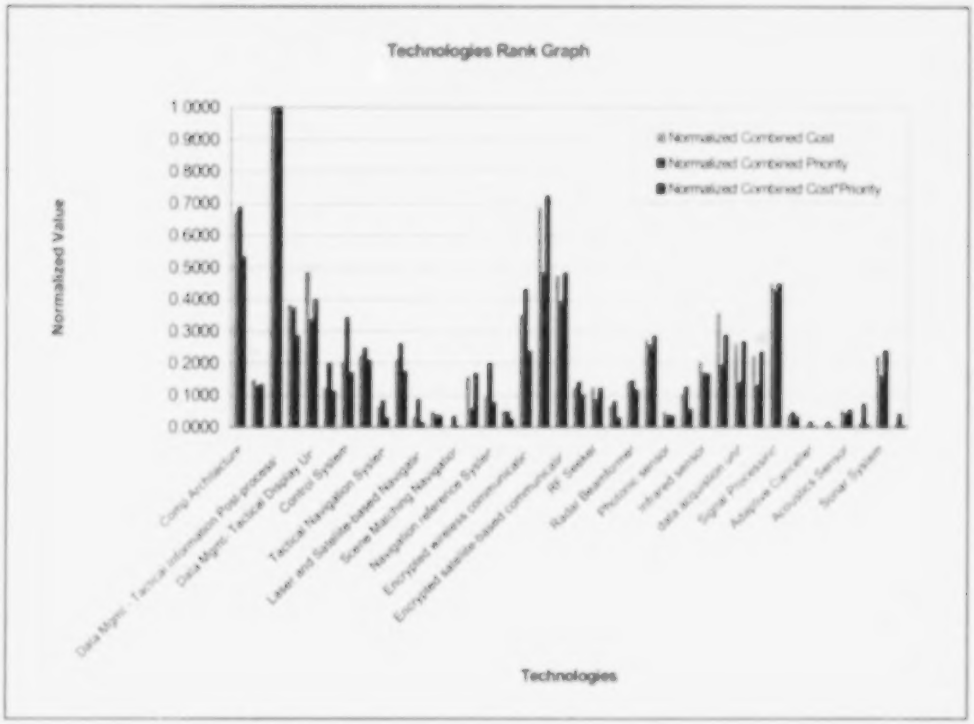

Figure 5. *Technologies Rank Graph*

Technology Rank Summary (Annex H)

Since each individual technology are classified into broader categories, the relative importance of each category can also be tabulated with the same method that has been used for the DUST Area. The cost factors of each individual technology listed under the same broader category are being added up and compared to total cost factor of the

other categories'. The sum of the priority factor, and the cost*priority factor are compiled the same way, as shown in Table 3.

Table 3. *Technology Rank Summary*

TECHNOLOGIES	NORMALIZED COMBINED COST OF TECHNOLOGIES	NORMALIZED COMBINED PRIORITY OF TECHNOLOGIES	NORMALIZED COMBINED COST FACTOR * PRIORITY FACTOR OF TECHNOLOGIES
Computer Architecture	0.6689	0.6877	0.5320
Data Mgmt - General Data Post-Processing	0.1470	0.1289	0.1331
Data Mgmt - Tactical Info Post-Processing	1.0000	1.0000	1.0000
Data Mgmt - General Display Unit	0.3824	0.3731	0.2856
Data Mgmt- Tactical Display Unit	0.4853	0.3359	0.3991
Data Mgmt - Information Database	0.1206	0.1998	0.1115
Control System	0.2023	0.3427	0.1698
Fire-control system	0.2238	0.2471	0.2091
Tactical Navigation System	0.0631	0.0830	0.0287
Satellite-based navigation	0.2071	0.2611	0.1736
Laser and Satellite-based Navigation	0.0323	0.0864	0.0131
Radar Navigation	0.0472	0.0362	0.0343
Scene Matching Navigation	0.0024	0.0333	0.0026
Inertial guidance system	0.1571	0.0574	0.1678
Navigation reference System	0.0935	0.1984	0.0764
Recording system	0.0490	0.0468	0.0236
Encrypted wireless communication	0.3500	0.4315	0.2364
Encrypted Wireless data link communication	0.6886	0.4821	0.7229
Encrypted satellite-based communication	0.4741	0.3929	0.4822
In-flight or in-vessel communication	0.1218	0.1409	0.1009
RF Seeker	0.1226	0.0849	0.1210
Transponder	0.0667	0.0806	0.0288
Radar Beamformer	0.1434	0.1453	0.1161
Radar Sensor	0.2734	0.2548	0.2847
Photonic sensor	0.0472	0.0362	0.0343
Laser range-finder/designator	0.1031	0.1264	0.0556
Infrared sensor	0.2046	0.1689	0.1668
Radar, phased-array Beamformer	0.3582	0.1926	0.2879
Data acquisition unit	0.2626	0.1400	0.2676
Target locator	0.2237	0.1308	0.2363
Signal Processing	0.4496	0.4281	0.4482
Synthetic Aperture	0.0374	0.0463	0.0323
Adaptive Canceller	0.0049	0.0159	0.0026
Adaptive Beamformer	0.0049	0.0159	0.0026
Acoustics Sensor	0.0508	0.0425	0.0533

Array Antenna	0.0111	0.0738	0.0078
Sonar System	0.2225	0.1597	0.2390
Anti-jamming mechanism	0.0087	0.0405	0.0051

Program Combined Analysis (Annex I)

This data sheet integrates all the relevant details of the defence programs and includes a graphical portrayal of Matching DUST Areas as suggested by [46];

An Excel version of the combined analysis data sheet provides a convenient way to sort and filter all entries, as illustrated in Figure 6.

Figure 6 - The pull-down filtering menu of the Program Combined Analysis chart

Array Antenna	0.0111	0.0738	0.0078
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Figure 6 - The pull-down filtering menu of the Program Combined Analysis chart

Table 4. DoD Capital Programs

CAPITAL PROGRAMS	FY2001	FY2002	FY2003	TOTAL
Aircraft				
AH-64D Longbow Apache	$772.2	$950.6	$941.7	$2,664.5
RAH-66 Comanche Helicopter	$590.8	$781.3	$910.2	$2,282.3
UH-60 Blackhawk Helicopter	$240.1	$416.3	$279.3	$935.7
OH-58D Kiowa Warior	$42.0	$44.6	$44.3	$130.9
MH-60S Helicopter	$314.6	$298.3	$395.5	$1,008.4
EA-6B Prowler	$272.5	$237.5	$290.4	$800.4
E-2C Hawkeye	$368.1	$312.6	$314.5	$995.2
F/A-18E/F Hornet	$2,949.3	$3,229.5	$3,267.3	$9,446.1
T-45TS Goshawk	$302.3	$183.4	$221.4	$707.1
MH-60R Helicopter	$132.1	$158.0	$205.2	$495.3
B-2 Stealth Bomber	$149.7	$240.5	$297.4	$687.6
C-17 Airlift Aircraft	$3,123.0	$3,871.8	$3,983.9	$10,978.7
CAP Civil Air Patrol	$6.3	$7.4	$2.6	$16.3
E-8C Joint Surveillance Target Attack Radar System (Joint Stars)	$432.3	$470.5	$334.8	$1,237.6
F-15E Eagle Multi-Mission Fighter	$752.7	$349.0	$314.2	$1,415.9
F-16 C/D Falcon Multi-Mission Fighter	$525.8	$346.4	$346.3	$1,218.5
F-22 Raptor	$3,948.1	$3,918.8	$5,248.3	$13,115.2
JPATS Joint Primary Aircraft Training System	$214.6	$254.3	$211.8	$680.7
JSF Joint Strike Fighter	$682.4	$1,524.9	$3,471.2	$5,678.5
UAV Unmanned Aerial Vehicle	$359.4	$970.9	$1,186.0	$2,516.3
V-22 Osprey	$1,430.2	$1,681.0	$1,994.0	$5,105.2
C-130J Airlift Aircraft	$791.8	$665.6	$545.5	$2,002.9
MUNITIONS				
ATACMS Army Tactical Missile System	$313.3	$183.3	$240.0	$736.6
JAVELIN AAWS-M	$318.8	$414.6	$251.0	$984.4
LONGBOW Hellfire Missile	$282.7	$240.1	$184.4	$707.2
MLRS Multiple Launch Rocket System	$202.6	$137.1	$141.1	$480.8
RAM Rolling Airframe Missile	$22.7	$42.7	$58.4	$123.8
STANDARD Missile (Air Defense)	$172.4	$170.1	$172.7	$515.2
TOMAHAWK Cruise Missile	$92.5	$149.3	$240.1	$481.9
TRIDENT II Sub Launched Ballistic Missile	$467.3	$575.0	$626.1	$1,668.4
SRAW Short Range Antitank	$54.3	$10.7	$44.6	$109.6
SFW Sensor Fused Weapon	$112.0	$108.8	$106.0	$326.8
WCMD Wind Corrected Dispenser	$100.3	$111.4	$71.2	$282.9
AMRAAM Advanced Medium Range Air-to-Air Missile	$195.0	$208.5	$185.6	$589.1
JASSM Joint Air to Surface Missile	$112.7	$125.8	$111.2	$349.7
JSOW Joint Standoff Weapon	$244.1	$56.0	$211.9	$512.0
JDAM Joint Direct Attack Munition	$311.4	$751.8	$830.2	$1,893.4
AIM-9X Sidewinder	$45.4	$84.8	$115.1	$245.3
NAVY VESSELS				
CVN-77 Aircraft Carrier	$4,352.1	$494.0	$603.4	$5,449.5

CAPITAL PROGRAMS	FY2001	FY2002	FY2003	TOTAL
DDG-51 AEGIS Destroyer	$3,467.0	$3,407.6	$2,670.2	$9,544.8
NSSN Virginia Class Submarine	$1,974.3	$2,467.9	$2,457.4	$6,899.6
LPD-17 San Antonio Class Amphibious Transport Ship	$593.8	$156.0	$614.6	$1,364.4
ADC (X) Auxiliary Dry Cargo Ship	$335.8	$360.8	$388.8	$1,085.4
ARMY COMBAT VEHICLES				
IAM Interim Armored Vehicles	$1,185.3	$767.5	$936.2	$2,889.0
M1A2 Abrams Tank Upgrade	$367.6	$574.2	$430.9	$1,372.7
M2A3 Bradley Base Sustainment	$425.4	$387.0	$397.1	$1,209.5
Crusader Artillery System	$341.8	$487.3	$475.2	$1,304.3
SPACE PROGRAMS				
Defense Satellite Comm Sys (Ground Sys)	$83.8	$112.6	$102.0	$298.4
DSP Defense Support Program	$114.8	$115.1	$116.5	$346.4
MLV Medium Launch Vehicles	$39.0	$39.5	$48.2	$126.7
MILSTAR Satellite Communications	$224.6	$228.7	$148.9	$602.2
NAVSTAR Global Positioning System	$400.8	$426.8	$633.8	$1,461.4
TITAN Heavy Launch Vehicle	$414.5	$373.2	$335.0	$1,122.7
EELV Evolved Expendable Launch Vehicle	$663.9	$413.3	$216.5	$1,293.7
SBIRS-H Space Based Infrared Sys - High	$550.1	$438.7	$814.9	$1,803.7
MUOS Mobile USER Objective System	$27.1	$3.0	$60.5	$90.6
OTHER PROGRAMS				
FHTV Family of Heavy Tactical Vehicles	$206.2	$161.5	$242.8	$610.5
FMTV Family of Medium Tactical Vehicles	$467.0	$466.1	$683.4	$1,616.5
MTVR Medium Tactical Vehicle Replacement	$325.2	$314.2	$380.5	$1,019.9
HMMWV High Mobility Multipurpose Wheeled Vehicles	$144.0	$151.3	$204.7	$500.0
SFW Sensor Fused Weapon	$112.0	$108.8	$106.0	$326.8
WCMD Wind Corrected Munitions Dispenser	$100.3	$111.4	$71.2	$282.9
ABL Airborne Laser	$386.1	$475.8	$598.0	$1,459.9
MD Missile Defense	$5,421.3	$7,775.0	$7,763.1	$20,959.4
Totals	**$44,171.6**	**$45,100.5**	**$49,895.2**	**$139,167.3**

Priorities for defence equipment acquisitions: The case of DoD of USA

The United States has entered a period that presents both opportunities and challenges. Although the threat of nuclear war has diminished there remain a number of uncertainties and potentially serious threats to America's security. Principal among these are regional dangers, asymmetric challenges and trans-national threats." President Bush said in February 2001, "We will modernize some existing weapons and equipment, [but] our goal is to move beyond marginal improvements to harness new technologies that will support a new strategy—to replace existing programs with new technologies and strategies: to skip a generation of technology . . . I intend to force new thinking and hard choices."

The Defense Department is heeding the President's guidance and seizing the opportunity to skip a generation in military capability. Already it has shelved the Navy's DD-21, the Navy Area Missile Defense system and 18 Army legacy programs including the Army's Crusader artillery system as being too heavy, cumbersome and lacking the transformational element of precision fire. This knowledge that the United States is already moving to acquire advanced military capabilities may serve as a powerful deterrent to any potential adversary. In the interim, relatively low-cost hedges can be put in place that guard against the uncertainty that the "leap-ahead" capabilities may not materialize as soon as forecast, or be as effective as anticipated.

The new approach is built on the doctrine that the U.S. must have the military capability to act any time, anywhere, in defence of what it sees as its global interests. The emphasis will continue to shift from soldiers to technology. The change of defence strategy will affect all the armed services and will have major implications for U.S. allies. The shift from Europe, which dominated U.S. strategic planning during the cold war, means a diminishing role for the army, which played the central role in strategy against Moscow. The new focus on East Asia, with China cast in the role of America's principal regional adversary, entails a bigger role for the navy and the air force in delivering U.S. military strike power. One of the ideological goals is to fight wars from a distance, minimizing loss of U.S. lives and maximizing political appeal.

Military strategy

The U.S. 1997 National Military Strategy provided the advice of the Chairman of the Joint Chiefs of Staff (CJCS) in consultation with the Joint Chiefs of Staff and the Combatant Commanders on the strategic direction of the Armed Forces over the past five years. In formulating the 1997 National Military Strategy, the CJCS derived guidance from the President's *1997 National Security Strategy* and from the *Quadrennial Defense Review* report prepared by the Secretary of Defense. The new 2001 Quadrennial Defense Review, (QDR), articulates the need to transform the U.S. military. It argues that the challenges and opportunities that confront the U.S. military are quite different from those encountered during the Cold War and Desert Storm, or even during the 1990s, and that greater change is forthcoming. Consequently, merely improving upon today's capabilities will not suffice to meet tomorrow's challenges. Moreover, the administration argues that the U.S. military also has the opportunity to make dramatic qualitative improvements in its capabilities, regardless of the threat's character.

The argument that the U.S. military needs to move beyond Cold War/Desert Storm era forms of conflict—and the two-major theater war posture they spawned—to address new challenges to America's security (and to exploit opportunities to improve its capabilities) is outlined in the QDR's "critical operational goals". These are summarized as:

- Protecting critical bases of operation, at home and abroad, and defeating CBRNE [chemical, biological, radiological, nuclear, and high-explosive] weapons and their delivery systems;
- Prevailing in information warfare, both in offensive and defensive operations;
- Projecting and sustaining U.S. forces in an anti-access/area-denial environment (A2/AD), and defeating A2/AD threats;
- , Denying enemies sanctuary from U.S. attack;
- Preserving the U.S. ability to operate effectively in space; and
- Leveraging information technologies and innovative operational concepts to develop an interoperable, joint C4ISR architecture.

Although the President's 2003 budget request, advances each of those transformational goals by accelerating transformation programs and funding the objectives, the two most formidable emerging challenges to confront the U.S. military will be homeland defence and anti-access/area-denial.

The 1997 National Military Strategy describes four strategic concepts that govern the use of forces to meet the demands of the strategic environment - overseas presence, decisive force, strategic agility and power projection. The latter two will remain key tenants in any future U.S. military strategy and will help dictate how forces are equipped. More specifically, strategic agility refers to the timely concentration, employment and sustainment of military power anywhere, at the nations own initiative, and at a speed and tempo that adversaries cannot match. It is an important hedge against uncertainties faced today. It allows the conduct of multiple missions, across the full range of military operations, in geographically separated regions of the world. Power projection is the ability to rapidly and effectively deploy and sustain military power in and from multiple, dispersed locations until conflict resolution. Power projection provides the flexibility to respond swiftly to crises, with force packages that can be adapted rapidly to the environment in which they must operate, and if necessary, fight their way into a denied theatre.

The October 2001 QDR establishes the basis for a "transformation" of the U.S. Armed Forces that seeks new defences, new methods, new equipment and just plain new thinking. There are four important new directions set in the QDR with which to establish equipment requirements and priorities:

- Moves away from the two Major Theatre War (MTW) force planning construct,
- Establishes a new framework for assessing risk,
- Shifts planning from "threat-based" model to "capabilities-based" model, and

- Determines what the strategic and operational challenges are and the goals to address them.

Deputy Secretary of Defense, Mr. Wolfowitz in his testimony to the Senate on Transformation, 9 April January 2002, stated that transformation can be thought of as innovation on a grand scale. That transformation is undertaken by a military that believes major changes are occurring in the character of conflict. Periods of military transformation are typically associated with a revolution in military affairs (RMA) in which a combination of technology, warfighting concepts and organizational change combine to bring about a dramatic leap in military effectiveness. Militaries are motivated to transform most often because they conclude either that very different operational challenges are arising that will greatly reduce the effectiveness of existing forces, or because they see an opportunity to develop new forms of operations themselves that will yield great advantage in future military competitions. He also reiterated that among other things, transformation is not:

- Solely based on introducing new technologies into the force. It also requires changes in the way the force is employed through major changes in doctrine and force structure;

- About enhancing efficiency in existing warfighting operational concepts; rather, it is about developing new warfighting concepts; or

- Just supplanting the entire force with new systems and force structures. The proper mix of existing and emerging systems and capabilities must be identified to deal with the new threat environment envisioned in defence strategy, while also exploiting sources of greatest potential advantage.

Even before the 11 September 2001 attack, senior DoD leaders were establishing a new defence that would embrace uncertainty and contend with surprise, a strategy premised on the idea that to be effective abroad, America must be safe at home. The resulting strategy is built around four key goals that will guide the development of U.S. forces and capabilities, their deployment and use:

- Assure allies and friends of the United States' steadiness of purpose and its capability to fulfill its security commitments;

- Dissuade adversaries from undertaking programs or operations that could threaten U.S. interests or those of its allies and friends;

- Deter aggression and coercion by deploying forward the capacity to swiftly defeat attacks and impose severe penalties for aggression on an adversary's military capability and supporting infrastructure; and

- Defeat any adversary decisively if deterrence fails.

A central objective of the review was to shift the basis of defence planning from a "threat-based" model that has dominated thinking in the past to a "capabilities-based" model for the future. This capabilities-based model focuses more on how an adversary might fight rather than specifically whom the adversary might be or where a war might occur. It recognizes that it is not enough to plan for large conventional wars in distant theatres. Instead, the United States must identify the capabilities required to deter and defeat adversaries who will rely on surprise, deception, and asymmetric warfare to achieve their objectives.

Regional security developments

U.S. military strategy takes into account new geopolitical trends shaping the world. Although the United States will not face a peer competitor in the near future, the potential exists for regional powers to develop sufficient capabilities to threaten stability in regions critical to U.S. interests. In particular, Asia is gradually emerging as a potential region for large-scale military competition. Maintaining a stable balance there would be a complex task with some states fielding large militaries and possessing the potential to develop or acquire Weapons of Mass Destruction (WMD). The distances are vast in the Asian theatre and the density of U.S. basing and en route infrastructure is lower than in other critical regions. The US also has less assurance of access to facilities in the region. This places a premium on securing additional access and infrastructure agreements and on developing systems capable of sustained operations at great distances with minimal theatre-based support.

The strategy also recognizes the diminishing protection afforded by geographic distance. As the September 2001 events demonstrated, the geographic position of the United States no longer guarantees immunity from direct attack on its population, territory, and infrastructure. Although the threat to the US and its overseas forces from Soviet missiles has subsided since the Cold War, an increasing number of states likely will acquire over time ballistic missiles with steadily increasing effective ranges. Moreover globalization and the attendant increase in travel and trade across U.S. borders has created new vulnerabilities to the U.S. homeland.

Key military technology trends

Technology in the military sphere is developing as rapidly as the tremendous changes reshaping the civilian sector. The combination of scientific advancement and globalization of commerce and communications have contributed to several trends that significantly affect U.S. defence strategy.

Rapid advancement of military technologies

The ongoing revolution in military affairs could change the conduct of military operations. Technologies for sensors, information processing, precision guidance, and many other areas are advancing rapidly. This poses the danger that states hostile to the United States could significantly enhance their capabilities by integrating widely available off-the-shelf technologies into their weapon systems and armed forces.

Increasing proliferation of CBRNE weapons and ballistic missiles

The pervasiveness of proliferation in an era of globalization has increased the availability of technologies and expertise needed to create the military means to challenge directly the United States and its allies and friends. This includes the spread of CBRNE weapons and their means of delivery, as well as advanced conventional weapons. Likewise, the biotechnology revolution holds the probability of increasing threats of biological warfare.

Emergence of new arenas of military competition

Technological advances create the potential that competitions will develop in space and cyber space. Space and information operations have become the backbone of networked, highly distributed commercial civilian and military capabilities. This opens up the possibility that space control – the exploitation of space and the denial of the use of space to adversaries – will become a key objective in future military competition. Similarly, states will likely develop offensive information operations and be compelled to devote resources to protecting critical information infrastructure from disruption, either physically or through cyber space.

Deterrent posture

Of the four defence policy goals noted earlier, "Deterring Threats and Coercion Against U.S. Interests" has major implications on how to assign priorities for funding and capital acquisition. A multi-faceted approach to deterrence requires forces and capabilities that provide the President with a wider range of military options to discourage aggression or any form of coercion. In particular, it places emphasis on peacetime forward deterrence in critical areas of the world. It requires enhancing the future capability of forward deployed and stationed forces, coupled with global intelligence, strike, and information assets, in order to deter aggression or coercion with only modest reinforcement from outside the theatre. Improving intelligence capabilities is particularly important, as these assets provide U.S. forces with critical information on adversaries' intentions, plans, strengths, and weaknesses. This new approach to deterrence also requires non-nuclear forces that can strike with precision at fixed and mobile targets throughout the depth of an adversary's territory; active and passive defences; and rapidly deployable and sustainable forces that can decisively defeat any adversary. A final aspect of deterrence, addressed in the Nuclear Posture Review is related to the offensive nuclear response capability of the US.

Moving to a capabilities-based force also requires the US to focus on emerging opportunities associated with advanced remote sensing, long-range precision strike, transformed manoeuvre and expeditionary forces and systems, and overcoming anti-access and area denial threats. The defence strategy also restores the emphasis once placed on defending the US and its land, sea, air, and space approaches. This is necessary to safeguard the Nation's way of life, its political institutions, and the source of its capacity to project decisive military power overseas. In turn, the ability to project power at long ranges helps to deter threats to the United States and, when necessary, to disrupt, deny, or destroy hostile entities at a distance. This requires forward forces capable of swiftly defeating an adversary's military and political objectives with only modest reinforcement. Key requirements for this reorientation include new combinations of immediately employable forward stationed and deployed forces; expeditionary and forcible entry capabilities; globally available reconnaissance, strike, command and control assets; information operations; special operations forces; and rapidly deployable, highly lethal and sustainable forces that may come from outside a theatre of operations.

Creating substantial margins of military advantage will require among many other elements, an ability to integrate highly distributed military forces in synergistic combinations for highly complex joint military operations. This becomes increasingly important as the strategy shifts from optimizing for conflicts in two particular regions - Northeast and Southwest Asia - to building a portfolio of capabilities that is robust across the spectrum of possible force requirements, both functional and geographical. New information and communications

technologies hold promise for networking highly distributed joint and combined forces and for ensuring that such forces have better situational awareness than in the past about friendly forces as well as those of adversaries. These communications will provide shared situational awareness but must be interoperable across all components including those of coalition partners. The capability provided by this network and its applications will enable rapid response forces to plan and execute faster than the enemy and to seize tactical opportunities. Standing Joint Task Force headquarters will have a standardized joint C4ISR architecture that provides a common relevant operational picture of the battle space for joint and combined forces.

However, the highest priority of the U.S. military remains one to defend the Nation from all enemies. The United States will maintain sufficient military forces to protect the U.S. domestic population, its territory, and its critical defence- related infrastructure against attacks emanating from outside U.S. borders. U.S. forces will provide strategic deterrence and air and missile defence and uphold U.S. commitments under NORAD. The continued proliferation of ballistic and cruise missiles poses a threat to U.S. territory, to U.S. forces abroad, at sea, and in space, and to U.S. allies and friends. To counter this threat, the United States is developing missile defences as a matter of priority. DoD has refocused and revitalized the missile defence program, shifting from a single-site "national" missile defence approach to a broad-based research, development, and testing effort aimed at deployment of layered missile defences. The U.S. military will be prepared to respond in a decisive manner to acts of international terrorism committed on U.S. territory or the territory of an ally.

Capabilities and forces located in the continental United States and in space are a critical element of this new global posture. Long-range strike aircraft and special operations forces provide an immediately employable supplement to forward forces to achieve a deterrent effect in peacetime. New forms of deterrence, emphasizing the strategic and operational effects that U.S. capabilities can impose upon an adversary, can incorporate globally distributed capabilities and forces to rapidly strike with precision mobile and fixed targets at various distances. In addition, the new planning approach requires the United States to maintain and prepare its forces for smaller-scale contingency operations in peacetime, preferably in concert with allies and friends.

In the interim, however, there is an overall urgent need for recapitalization of legacy systems by replacement, selected upgrade, and life extension. DoD plans to pursue selective upgrades to systems such as Abrams tanks, B-1 bombers, Navy ship self-defence, and amphibious assault vehicles to sustain capabilities critical to ensuring success in any near-term conflict.

Characteristics of a full spectrum Force

In general terms, U.S. Armed Forces must be multi-mission capable, interoperable among all elements of U.S. Services and selected foreign militaries, and able to coordinate operations with other agencies of government, and some civil institutions. These broad concepts, along with ideas of Rear Adm. (Ret.) Stephen H. Baker, Centre for Defence Information (CDI) Senior Fellow, as compiled on 26 Oct 2001 are developed further in the following paragraphs with respect to initiatives, technologies and programs that should receive top funding priority.

Multi-mission capable

The correct mix of capabilities that exploits advanced technology is required between and within the Services, and among conventional, nuclear, and special operations

forces. The wide range of likely military operations will require a quick shift from one type of operation to another regardless of an adversary's use of asymmetric means.

Joint

Each Service, including the U.S. Coast Guard, brings its own set of capabilities and strengths to a mission. The skilful and selective combination of Service capabilities into Joint Task Forces provides U.S. commanders great flexibility in tailoring forces. A fully joint force requires joint operational concepts, doctrine, tactics, techniques, and procedures as well as institutional, organizational, intellectual, and system interoperability. This will enable all U.S. forces and systems to operate coherently at the strategic, operational, or tactical levels. These joint forces will be used to manage crises, forestall conflict, and conduct combat operations. They must be lighter, more lethal and manoeuvrable, survivable, and more readily deployed and employed in an integrated fashion. They must be not only be capable of conducting distributed and dispersed operations, but also able to force entry in anti-access or area-denial environments.

Interoperability

All elements of U.S. joint and combined forces must be able to work together smoothly. Success on the home front working with other U.S. government agencies, and with Non-governmental Organizations and on the battlefield will depend on the operational and tactical synergy of integrated, agile military forces. Laying a solid foundation for interoperability with alliance and potential coalition partners is fundamental to effective combined operations.

Strategic deterrence

Credible standing nuclear and conventional forces cause potential adversaries to consider the consequences of pursuing aggression. Although most nuclear powers continue to reduce their arsenals, the U.S. triad of strategic forces serves as a vital hedge against an uncertain future, a guarantor of security commitments to its allies, and a deterrent to those who would contemplate developing or otherwise acquiring their own nuclear weapons. Strategic nuclear weapons remain the keystone of U.S. deterrent strategy. A mix of forward deployable non-strategic nuclear and conventional weapons adds credibility to its commitments. Deterrence is further enhanced by the ability of U.S. forces to attack targets even when access to regional bases may not be feasible or assured. Geography and political constraints on access will not restrict its ability to conduct long range, stand-off attacks against a full range of targets in hostile territory.

Countering Weapons of Mass Destruction

The continued proliferation of WMD, particularly chemical and biological weapons, makes their employment by an adversary increasingly likely in both major theatre war and smaller-scale contingencies. U.S. forces must have a counter-proliferation capability balanced among the requirements to prevent the spread of WMD through engagement activities; detect an adversary's possession and intention to use WMD; destroy WMD before they can be used; deter or counter WMD; protect the force from

the effects of WMD through training, detection, equipment, and immunization; and restore areas affected by the employment of WMD through containment, neutralization, and decontamination. Since many operations will be conducted as part of an alliance or coalition, friends and allies must be encouraged to train and equip their forces for effective operations in environments where WMD usage is likely.

Mobility

The successful application of military power is dependent on uninhibited access to air and sea. Control of these mediums allows the United States to project power across great distances, conduct military operations, and protect its interests around the world. U.S. forces must always seek to gain superiority in, and dominance of the air and sea to allow its forces freedom to conduct operations and to protect both military and commercial assets. The increasingly difficulty and inefficiency of pre-positioning forces for theatre operations requires continued efforts to improve the transportability and flexibility of U.S. forces such as the example of the Army's new air-transportable, multi-wheeled, armoured vehicle, the Stryker.

The concept of mobility also includes continued upgrades and expansion of the sealift and fixed-wing airlift fleets, improved capabilities of the existing fleet of helicopters with an emphasis on supporting Special Forces operations, and replacement of the Air Force's aging airborne tanker fleet. It also includes improvements and security upgrades at domestic embarkation locations.

Sealift

One of the principal shortfalls faced by the United States military is its ability of its lift assets to support two major theatre wars. This shortfall continues to emerge as one of the greatest threats to the U.S. ability to successfully execute the national military strategy. General John W. Handy, USAF, Nominee for Commander In Chief, Transportation Command on 25 September 2001, opined that there is a need for specialty ships such as Float-on/Float-off and Heavy Lift sealift, Navy Mine Countermeasure vessels, and Coast Guard patrol craft. Robust strategic sealift combined with pre-positioned supplies and equipment ashore and afloat, are critical to maintaining strategic agility and are essential for opening ports and force protection during normal or port denial operations.

General Handy also stated that efforts need to continue to improve detection, protection, and decontamination capabilities from WMD at air and seaports as well as the assets critical to the Defense Transportation System. Vulnerability assessments need to be conducted at critical transportation locations, with necessary follow-on actions taken to ensure that those critical assets are protected.

Airlift

General Handy saw airlift to be the most pressing challenge. Initial review of the new strategy, coupled with service transformation efforts, led him to conclude that strategic mobility will become more demanding not less,

validating the need for additional (50-60) C-17s and a robust C-5 modernization program. Robust air mobility combined with pre-positioned supplies and equipment are critical to maintaining strategic agility and facilitating the ability to protect national interests and assisting allies when needed. Compounding this problem are the significant problems with the readiness of the C-5 aircraft. The Air Force is pursuing a two-pronged approach of upgrading avionics for all C-5s, and initially only putting new engines on the newer C-5B aircraft. The C-17 and C-5 are the only two aircraft capable of carrying oversize and outsize cargo. The 50 C-5Bs are only 12 years old and are equipped with air defensive systems. They fly much more on a day-to-day basis than the 76 thirty-five-year old C-5As.

Intelligence/Surveillance/Reconnaissance

Armed Forces require the timely collection, evaluation, and assessment of a full range of geo-political, socio-economic, and military information throughout the full spectrum of conflict. A globally vigilant intelligence system that is able to operate in a complex environment with an increasing number of potential opponents and more sophisticated technology is critical. It should include a space-based capability for real-time radar tracking of mobile targets on land or sea. It must overcome increasingly varied means of deception and protect and secure its information channels. It must respond to the war fighters' needs during compressed decision cycles, and accommodate 'smart' and 'brilliant' weapons systems that pass targeting information directly to weapons platforms.

Command and Control

Data management is one of the keys to the modern battlefield. The ability to gather, process, and disseminate an uninterrupted flow of reliable and precise information under any conditions is a tremendous strategic and military advantage. Tactical intelligence about the enemy, status of friendly forces, terrain, weather, and literally hundreds of other pieces of information have to be gathered, sifted, interpreted and integrated into an ever-changing battle plan. Development of "network-centric" warfare — using a system of systems to make data available to those who need it across the organization or on the battlefield is seen as a priority along with a secure C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) architecture. This should be designed and developed from the outset for rapid deployment and with joint and multi-national interoperability in mind.

Information operations

IT surfaces in two QDR operational goals: 1) viewing IT as a critical asset that needs to be defended in and of itself, and 2) as the enabler for bringing about Defense Secretary Rumsfeld's transformation of U.S. armed forces. The report states "Information technology will provide a key foundation for the effort to transform U.S. armed forces for the 21st century". Success in any operation depends on the ability to quickly and accurately integrate critical information and deny the same to an adversary. Information superiority must be attained throughout the conduct of both offensive and defensive information operations. Information operations are, however, more than discrete

offensive and defensive actions; they are also the collection and provision of that information to the war fighters. Superiority in these areas will enable commanders to contend with information threats to their forces, including attacks that may originate from outside their area of operations. It also limits an adversary's freedom of action by disabling his critical information systems.

Force protection

Beginning at home, multiple layers of protection enable U.S. forces to maintain freedom of action throughout the spectrum of conflict. Fluid battlefields and the potential ability of adversaries to orchestrate asymmetric threats require the pursuit of every means to protection. Comprehensive force protection requires the employment of a full array of active and passive measures as highlighted by the Navy's decision in November 2001 to restructure the DD-21 program. In lieu of proceeding with the single DD-21 class of destroyers, the Navy has decided to develop a "family of advanced technology surface combatants," comprising a land-attack destroyer (DD-X), a guided-missile cruiser (CG-X), and a Littoral Combat Ship (LCS). The variety of challenges faced by the U.S. may also require less than lethal technology to meet demands at the lower end of the range of military operations. Force protection initiatives must thus address all aspects of potential threats, to include terrorism, WMD, information operations, and theatre ballistic and cruise missiles.

Forcible entry

U.S. global strategy requires the ability to inject military forces into foreign territories in a non-permissive environment. While the U.S. will pursue the cooperation of other governments to grant its forces access, it must not assume that such cooperation will always be forthcoming. A forced entry capability ensures that the U.S. will always be able to gain access to seaports, airfields, and other critical facilities that might otherwise be denied. It reassures allies that its ability to come to their aid cannot be denied by an enemy. It also allows future joint force commanders to retain operational freedom of action and gives them the ability to go anywhere that its interests require.

UAVs/UCAVs

Unmanned Aerial Vehicles (UAVs) have become a source for accurate real-time intelligence and combat variants, (UCAVs), are reportedly now operational in Afghanistan. However, relatively few UAVs are available. For example, the Air Force has as few as seven low altitude Predators available for immediate operations and four medium altitude Global Hawks with plans to buy 6 more by 2006. A New York Times article of 1 October 2001 reported that Northrop Grumman had proposed doubling its output and moving up delivery of the next two aircraft to the end of 2002. The Defense Authorization Act for fiscal year (FY) 2001 states "it shall be a goal of the Armed Forces to achieve the fielding of unmanned, remotely controlled technology such that...by 2010, one-third of the aircraft in the operational deep strike force aircraft fleet are unmanned." An 8 August press release indicates a major funding commitment of approximately $300M USD for the accelerated acquisition of UAVs.

Precision Guided Munitions

Since Operation Desert Storm, the United States has increasingly used Precision Guided Munitions (PGMs) — cruise missiles and "smart" bombs — as the weapons of choice in attacking ground targets. It was reported by Dan Caterinicchia Feb. 6, 2002 Federal Computer Week that Retired Navy Vice Adm. Arthur Cebrowski said sensor technology is one area poised to receive significantly more funding: - "We are seeing the emergence of sensor-based warfare. The reality is, the world knows if we can sense it, we can kill it." That has led to our enemies cloaking themselves, their weapons and systems more effectively than in the past, Cebrowski said. Gerry J. Gilmore reported in American Forces Press Service Washington, 16 May 2002 that Rumsfeld said that in Afghanistan, it was found that "precision matters, and it matters a lot," Besides achieving better accuracy, he noted, use of precision munitions reduced the incidence of military 'friendly fire' losses and civilian casualties and that about 65 percent of U.S. munitions used in Afghanistan were precision-guided. Precision munitions enabled U.S. Special Forces on the ground in Afghanistan to call in "long-range bombers to provide tactical, close-air support," Rumsfeld noted. It follows, that stocks of the latest PGMs, which use Global Positioning System (GPS) guidance will be expanded and the development and fielding of the next generation of "smart" bombs and cruise missiles will be accelerated. This includes the development of the Small Diameter Bomb, which would allow more targets to be attacked per sortie and with less collateral damage; and increasing the inventory of GPS guided, sea-launched Tomahawk Block 3 models. While GPS weapons are clearly higher priority, a significant inventory of laser-guided, optically guided and terrain-guided PGMs should be maintained. In future conflicts, potential enemies with greater technological sophistication than those faced to date will likely attempt to disable, temporarily if not permanently, the U.S. GPS network.

Aircraft self-protection equipment

While air strikes can be extremely effective in eliminating an enemy's static air defence network, shoulder-held, man-portable, surface-to-air missiles remain a threat for the duration of any conflict. They have proven to be particularly effective against helicopters, which are integral for ground operations and in support of Special Forces. Countermeasures require continuous improvement and new technologies and tactics need to be developed such as the integrated electronic/infrared warning and defence system being developed by the Navy.

Accelerated digitization of the Soldier

On the modern battlefield, direct access to real-time data is essential for maintaining situational awareness. This is particularly critical for forces operating autonomously in a hostile environment (i.e., behind enemy lines). Efforts to provide necessary, user-friendly information in a timely manner and interconnect the soldiers on the battlefield should be expanded and accelerated.

Mine detection/Clearing

In certain situations, one of the greatest threats to U.S. troops on the battlefield is the presence of landmines and unexploded ordnance. For obvious logistical reasons, certain

areas of operation and situations preclude the use of large mine-clearing equipment, or insufficient time exists for the removal of individual explosives. Easily deployable mine detection/clearing technologies, with both combat and peacetime uses, should be developed.

Cooperative threat reduction program

It is essential to continue to develop and expand capabilities to counter the proliferation of weapons of mass destruction and their related technologies. These are seen as the greatest threat to U.S. national security.

Section summary

The above are deemed to be the major characteristics that need to be considered in developing priorities for equipment of a full spectrum military. These are supported by the opinion of *Andrew F. Krepinevich, Executive Director, Center for Strategic and Budgetary Assessments* in his testimony to the U.S. Senate Committee on Armed Services on 9 April 2002, that to meet the critical operational goals of the 2001 QDR, U.S. military will have to be transformed into a fighting force that places substantially greater emphasis on the following characteristics:

- Mobility
- Stealth (in all its forms, to include undersea forces)
- Electronic protection
- Highly dispersed, electronically networked combat forces and supporting elements (e.g., logistics)
- Highly distributed insertion through non-traditional air and sea points of debarkation
- Extended-range systems and strikes
- Precision, electronic, and non-lethal forms of strike
- Unmanned/automated systems
- Compressed operational cycle rates

Theoretical analysis for Dual Use Technologies: Case of sonar, radar and medical imaging signal processing concept similarities

Advancements in the areas of *sonar and radar systems technologies* have resulted primarily from the work of military and other government departments in striving to improve the capabilities of their Anti-Submarine Warfare (ASW) sonar and radar systems. Detailed descriptions of mainstream signal processing functions along with their associated implementation considerations can be found in the referenced articles on sonar [1,3,4,5], radar [2,3] and medical imaging [3,6-14] system technologies. A secondary aim of the present analysis is to promote, where possible, wider dissemination of this military-inspired research in civilian system application areas of information technologies, such as medical imaging.

Overview of a real time system

To provide a context for the material contained in this section, the basic requirements of a high-performance real time system will be reviewed. Figure 4 shows one possible high-level view of a generic system [15]. It consists of an array of sensors and / or sources, a high-speed *signal processor* to provide mainstream signal processing for detection and initial parameter estimation, a *data manager,* which supports the data and information processing functionality of the system, and a *display sub-system* through which the system operator can interact with the data structures in the data manager to make the most effective use of available resources.

In this section we will limit our attention to the *signal processor,* the *data manager* and *display sub-system*, which consist of the algorithms and the processing architectures required for their implementation. *Arrays of sources and sensors* include devices of varying degrees of complexity that illuminate the medium of interest and sense the existence of signals of interest. These devices are arrays of transducer having cylindrical, spherical, plane or line geometric configurations, depending on the application of interest. Quantitative estimates of the various benefits that result from the deployment of arrays of transducers are obtained by the *array gain* term. Sensor array design concepts, however, are beyond the scope of this analysis and readers interested in transducers can refer to other publications on the topic [16-19].

The *signal processor* is probably the single most important component of a real-time system of interest for this section. In order to satisfy the basic requirements, the processor normally incorporates the following fundamental operations:

- Multi-dimensional beamforming;
- Matched filtering;
- Temporal & spatial spectral analysis;
- Tomography image reconstruction processing; and
- Multi-dimensional image processing.

The first three processes are used to improve both the signal-to-noise ratio (SNR) and parameter estimation capability through spatial and temporal processing techniques. The next two operations are image reconstruction and processing schemes associated mainly with image processing applications. As indicated in Figure 7, the replacement of the *existing signal processor* with a *new signal processor* that would include advanced processing schemes, could lead into improved performance functionality of a real time system of interest, while the associated development cost could be significantly lower than using other hardware alternatives. In a sense, this statement highlights the future trends of state of the art investigations on advanced real time signal processing functionalities that are the subject of the handbook at [42].

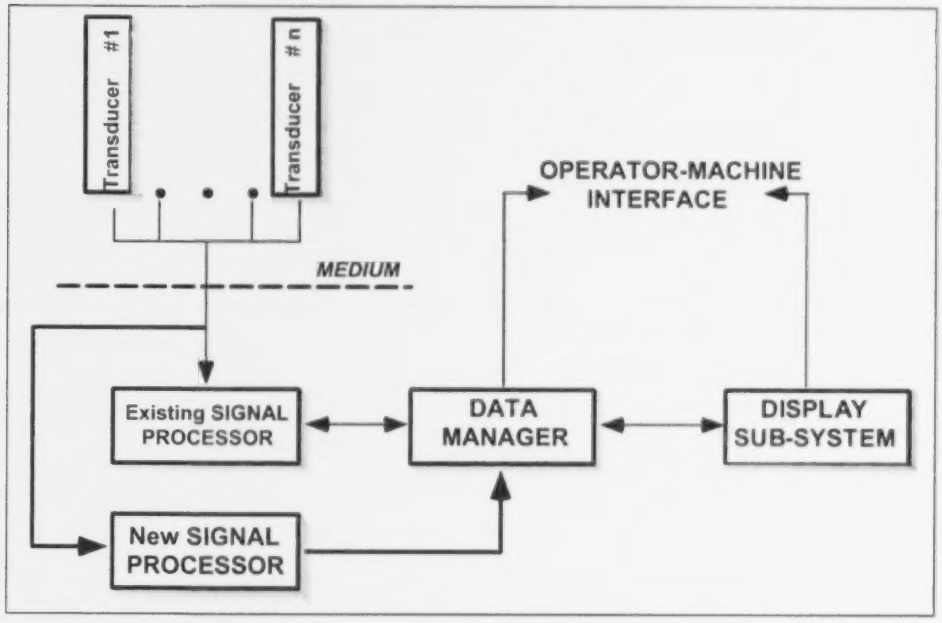


Figure 7. Overview of Generic Real Time System

Post-processing of the information provided by the previous operations includes mainly:

- Signal tracking and target motion analysis;
- Image post-processing and data fusion;
- Data normalization; and
- OR-ing

These operations form the functionality of the *data manager* of sonar and radar systems. However, identification of the processing concept similarities between sonar, radar and medical imaging systems may be valuable in identifying the implementation of the above operations in other medical imaging system applications. In particular, the operation of data normalization in sonar and radar systems is required to map the resulting data into the dynamic range of the

display devices in a manner which provides a Constant False Alarm Rate (CFAR) capability across the analysis cells. The same operation, however, is required in the display functionality of medical ultrasound imaging systems as well.

In what follows, each sub-system, shown in Figure 4, is examined briefly by associating the evolution of its functionality and characteristics with the corresponding signal processing technological developments.

Signal processor

The implementation of signal processing concepts in real-time systems is heavily dependent on the computing architecture characteristics and it therefore is limited by the progress made in this field. While the mathematical foundations of the signal processing algorithms have been known for many years, it was the introduction of the microprocessor and high-speed multiplier-accumulator devices in the early 1970's, which heralded the turning point in the development of digital systems. The first systems were primarily fixed-point machines with limited dynamic range and hence were constrained to use conventional beamforming and filtering techniques [1,4,15]. As floating-point central processing units (CPUs) and supporting memory devices were introduced in the mid to late 70's, multi-processor digital systems and modern signal processing algorithms could be considered for implementation in real-time systems. This major breakthrough expanded in the 1980's into massively parallel architectures supporting multi-sensor requirements.

The limitations associated with these massively parallel architectures became evident by the fact that they allow only fast-Fourier-transform (FFT) vector-based processing schemes because of their very efficient implementation and of their very cost-effective throughput characteristics. Thus, non-conventional schemes (i.e. adaptive, synthetic-aperture and high-resolution processing) could not be implemented in these types of real time systems of interest, even though their theoretical and experimental developments suggest that they have advantages over existing conventional processing approaches [2,3,15,20-25]. It is widely believed that these advantages can address the requirements associated with the difficult operational problems that next generation real time sonar, radar and medical imaging systems will have to solve.

New scalable computing architectures, however, which support both scalar and vector operations satisfying high input/output bandwidth requirements of large multi-sensor systems, are becoming available [15]. Frequent recent announcements include successful developments of super-scalar and massively parallel signal processing computers that have throughput capabilities of hundred of billions of floating point operation per second (GFLOPS) [31]. This resulted in a resurgence of interest in algorithm development of new covariance-based high-resolution, adaptive [15,20-22,25] and synthetic-aperture beamforming algorithms [15,23], and time-frequency analysis techniques [24].

References [15,20-22,25] discuss in some detail the recent developments in adaptive, high-resolution and synthetic aperture array signal processing and their advantages for real-time system applications. In particular, they review the basic issues involved in the study of adaptive systems for signal processing. The virtues of this approach to statistical signal processing may be summarized as follows:

- The use of an adaptive filtering algorithm, which enables the system to adjust its free parameters (in a supervised or unsupervised manner) in accordance with the underlying

statistics of the environment in which the system operates. Hence, the need for determining the statistical characteristics of the environment is avoided.

- Tracking capability, which permits the system to follow statistical variations of the environment.

- The availability of many different adaptive filtering algorithms, both linear and non-linear, which can be used to deal with a wide variety of signal-processing applications in radar, sonar and biomedical imaging.

- Digital implementation of the adaptive filtering algorithms, which can be carried out in hardware or software form.

In many cases, however, special attention is required to non-linear, non-Gaussian signal processing applications. Chapter 3 in [42] addresses this topic by introducing a Gaussian mixture approach, as a model is such problems where data can be viewed as arising from two or more populations mixed in varying proportions. Using the Gaussian mixture formulation, problems are treated from a global viewpoint that readily yields and unifies previous, seemingly unrelated results. The material of Chapter 3 in [42] introduces novel signal processing techniques applied in application problems, such as target tracking in polar coordinates and interference rejection in impulsive channels.

In other cases these advanced algorithms, introduced in [42 i.e. Chapters 2 and 3], trade robustness for improved performance [15,25,26]. Furthermore, the improvements achieved are generally not uniform across all signal and noise environments of operational scenarios. The challenge is to develop a concept that allows an appropriate mixture of these algorithms to be implemented in practical real time systems. The advent of new adaptive processing techniques is only the first step in the use of *a priori* information as well as more detailed information for the mediums of the propagating signals of interest. Of particular interest is the rapidly growing field of Matched Field Processing (MFP) [26]. The use of linear models will also be challenged by techniques that utilize higher-order statistics [24], neural networks [27], fuzzy systems [28], chaos and other non-linear approaches. Although these concerns have been discussed [27] in a special issue of the IEEE Journal of Oceanic Engineering devoted to sonar system technology, it should be noted that a detailed examination of MFP can be found also in the July 1993 issue of this journal, which has been devoted to detection and estimation of MFP [29].

The discussion in [42, i.e. Chapter 4] focuses on the class of problems for which there is some information about the signal propagation model. From the basic formalism of a blind system identification process, signal processing methods are derived that can be used to determine the unknown parameters of the medium transfer function; and demonstrate its performance for estimating the source location and the environmental parameters of a shallow water wave guide. Moreover, the system concept similarities between sonar and ultrasound systems are analyzed in order to exploit the use of model based sonar signal processing concepts in ultrasound problems.

The discussion on model-based signal processing is extended in [42, i.e. Chapter 5] to determine the most appropriate signal processing approaches for measurements that are contaminated with noise and underlying uncertainties. In general, if the SNR of the measurements is high, then simple non-physical techniques such as Fourier transform-based temporal and spatial processing schemes can be used to extract the desired information. However, if the SNR is extremely low and/or the propagation medium is uncertain, then more

of the underlying propagation physics must be incorporated somehow into the processor to extract the information. These are issues that are discussed in [42, i.e. Chapter 5] that introduce a generic development of MBP schemes and then concentrates specifically on those designed for sonar system applications.

Thus, the chapters 2, 3, 4, 5, 6 and 11 in [42] address a major issue: the implementation of advanced processing schemes in real-time systems of interest. It is pointed out that the starting point will be to identify the signal processing concept similarities among radar, sonar and medical imaging systems by defining a generic signal processing structure integrating the processing functionalities of the real time systems of interest. The definition of a generic signal processing structure for a variety of systems will address the above continuing interest that is supported by the fact that synthetic-aperture and adaptive processing techniques provide new gain [2,15,20,21,23]. This kind of improvement in array gain is equivalent to improvements in system performance.

In general, improvements in system performance or array gain improvements are required when the noise environment of an operational system is non-isotropic, such as the noise environment of: (1) atmospheric noise or clutter (radar applications), (2) cluttered coastal waters and areas with high shipping density in which sonar systems operate (sonar applications), and (3) the complexity of the human body (medical imaging applications). An alternative approach to improve the array gain of a real-time system requires the deployment of very large aperture arrays, which leads to technical and operational implications. Thus, the implementation of non-conventional signal processing schemes in operational systems will minimize very costly hardware requirements associated with array gain improvements.

Shown in Figure 8, is the configuration of a generic signal processing scheme integrating the functionality of radar, sonar, ultrasound and medical tomography CT/X-ray and MRI imaging systems. There are five major and distinct processing blocks in the generic structure. Moreover, reconfiguration of the different processing blocks of Figure 8 allows the application of the proposed concepts to a variety of active or passive digital signal processing (DSP) systems.

The first point of the generic processing flow configuration is that its implementation is in the frequency domain. The second point is that, with proper selection of filtering weights and careful data partitioning, the frequency-domain outputs of conventional or advanced processing schemes can be made equivalent to the Fast Fourier Transform (FFT) of the broadband outputs. This equivalence corresponds to implementing Finite Impulse Response (FIR) filters via circular convolution with the FFT and it allows spatial-temporal processing of narrowband and broadband type of signals [2,15,30], as defined in Chapter 6 of the handbook at [42]. Thus, each processing block in the generic DSP structure provides continuous time series; and this is the central point of the implementation concept that allows the integration of quite diverse processing schemes, such as those shown in Figure 8.

More specific details of the generic processing flow of Figure 8 are briefly discussed in the following paragraphs.

Signal Conditioning of Array Sensor Time Series

The block titled *Signal Conditioning for Array Sensor Time Series* includes the partitioning of the time series from the receiving sensor array, their initial spectral FFT, the selection of the signal's frequency band of interest via band-pass FIR filters and down-sampling. The output of this block provides continuous-time series at reduced

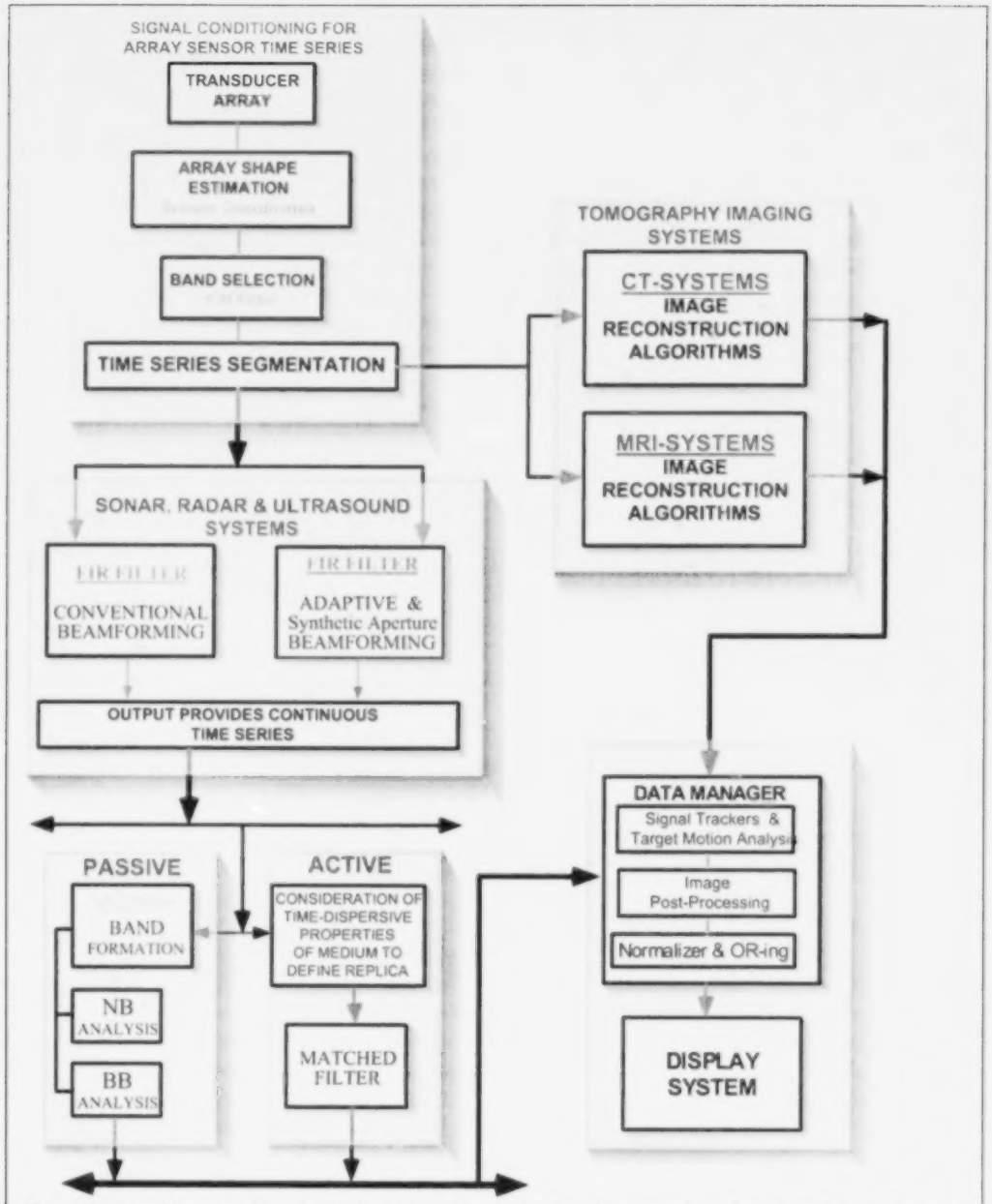
sampling rate, for improved temporal spectral resolution. In many system applications including moving arrays of sensors, array shape estimation or the sensor coordinates would be required to be integrated with the signal processing functionality of the system, as shown in this block.

Typical system requirements of this kind are towed array sonars [15] discussed in [42, i.e. Chapters 6, 10 and 11]; CT/X-ray tomography systems [6-8], which are analyzed in [42, i.e. Chapters 15 and 16]; and ultrasound imaging systems deploying long line or planar arrays [8-10] that are discussed in [42, i.e. Chapters 6, 7, 13 and 14].

The processing details of this block are illustrated in schematic diagrams in [42, i.e. Chapter 6]. The FIR band selection processing of this block is typical in all the real time systems of interest. As a result, its output can be provided as input to the blocks named: *Sonar, Radar & Ultrasound Systems*, or *Tomography Imaging CT/X-ray & MRI Systems*.

Tomography Imaging X-ray CT and MRI Systems

The block at the right-hand side of Figure 8, which is titled *Tomography Imaging CT/X-ray & MRI Systems*, includes image reconstruction algorithms for medical imaging CT/X-ray and MRI systems. The processing details of these algorithms are discussed in [42, i.e. Chapters 15, 16]. In general, image reconstruction algorithms [6,7,11-13] are distinct processing schemes and their implementation is practically efficient in CT and MRI applications. However, tomography imaging and the associated image reconstruction algorithms can be applied in other system applications such as, diffraction tomography using ultrasound sources [8] and acoustic tomography of the ground using various acoustic frequency regimes. Diffraction tomography is not practical for medical imaging applications because of the very poor image resolution and the very high absorption rate of the acoustic energy by the bone structure of the human body. In geophysical applications, however, seismic waves can be used in tomographic imaging procedures to detect and classify very large buried objects. On the other hand, working with higher acoustic frequencies, a better image resolution would allow detection and classification of small shallow buried objects such as anti-personnel land mines [41], which is a major humanitarian issue that has attracted the interest of U.N and the highly industrialized countries in North America and Europe. The rule of thumb in acoustic tomography imaging applications is that higher frequency regimes in radiated acoustic energy would provide better image resolution at the expense of higher absorption rates for the radiated energy penetrating the medium of interest. All these issues and the relevant industrial applications of computed tomography imaging are discussed in [42, i.e. Chapter 15].



Generic signal processing structure integrating the signal processing functionalities of sonar, radar, ultrasound, CT/X-ray and MRI medical imaging systems.

Figure 8. *Generic Signal Processing Structure*

Sonar, Radar and Ultrasound Systems

The underlying signal processing functionality in sonar, radar and modern ultrasound imaging systems deploying line, planar, cylindrical or spherical array, is beamforming. Thus, the block in Figure 8 titled *Sonar, Radar & Ultrasound Systems*, includes such sub-blocks as *FIR Filter/Conventional Beamformer* and *FIR Filter/Adaptive & Synthetic-Aperture Beamformers* for multi-dimensional arrays with line, planar, circular, cylindrical and spherical geometric configurations. The output of this block provides continuous directional beam time series by using the FIR implementation scheme of the spatial filtering via circular convolution. The segmentation and overlap of the time series at the input of the beamformers takes care of the wraparound errors that arise in fast-convolution signal processing operations. The overlap size is equal to the effective FIR filter's length [15,30]. Chapter 6 in [42] discusses in detail the conventional, adaptive and synthetic aperture beamformers that can be implemented in this block of the generic processing structure of Figure 5. Moreover, Chapters 6 and 11 in [42] provide some real data output results from sonar systems deploying line or cylindrical arrays.

Active and Passive Systems

The blocks named *Passive* and *Active* in the generic structure of Figure 8 are the last major processes that are included in most of the DSP systems. Inputs to these blocks are continuous beam time series, which are the outputs of the conventional and advanced beamformers of the previous block. However, continuous sensor time series from the first block titled *Signal Conditioning of Array Sensor Time Series* can be provided as the input of the *Active* & *Passive* blocks for temporal spectral analysis. The block titled *Active* includes a *Matched Filter* for the processing of active signals. The option here is to include the medium's propagation characteristics in the replica of the active signal considered in the matched filter in order to improve detection and gain [15,26]. The blocks *Vernier/Band Formation* and *Narrowband, Broadband Spectral Analysis* include the final processing steps of a temporal spectral analysis for the beam time series. The inclusion of the *Vernier* here is to allow the option for improved frequency resolution. Chapter 11 in [42] discusses the signal processing functionality and system oriented applications associated with active and passive sonars. Furthermore, Chapter 13 in [42] extends the discussion to address the signal processing issues relevant with ultrasound medical imaging systems.

In summary, the strength of the generic processing structure of Figure 8 is that it identifies and exploits the processing concept similarities among radar, sonar and medical imaging systems. Moreover, it enables the implementation of non-linear signal processing methods, adaptive and synthetic-aperture, as well as the equivalent conventional approaches. This kind of parallel functionality for conventional and advanced processing schemes allows for a very cost-effective evaluation of any type of improvement during the concept demonstration phase.

As stated above, the derivation of the effective filter length of an FIR adaptive and synthetic-aperture filtering operation is essential for any type of application that will allow simultaneous narrowband and broadband signal processing. This is an important

problem because of the dynamic characteristics of the adaptive algorithms; and it has not as yet been addressed.

In the past, attempts to implement matrix-based signal processing methods, such as adaptive processing, were based on the development of systolic array hardware because systolic arrays allow large amounts of parallel computation to be performed efficiently since communications occur locally. Unfortunately systolic arrays have been much less successful in practice than in theory. Systolic arrays big enough for real problems cannot fit on one board, much less on one chip, and interconnects have problems. A 2-D systolic array implementation will be even more difficult. Recent announcements, however, include successful developments of super-scalar and massively parallel signal processing computers that have throughput capabilities of hundred of billions of floating point operation per second (GFLOPS) [40]. It is anticipated that these recent computing architecture developments will address the computationally intensive scalar and matrix-based operations of advanced signal processing schemes for next generation real-time systems.

Data Manager and Display Subsystem

The block *Data Manager and Display Subsystem*, in Figure 8, includes normalizers, target motion analysis, image post-processing and OR-ing operations to map the output results into the dynamic range of the display devices; and this will be discussed in the next section.

Data Manager and Display Sub-System

Processed data at the output of the mainstream signal processing system must be stored in a temporary database before they are presented to the system operator for analysis. Until very recently, owing to the physical size and cost associated with constructing large databases, the *data manager* played a relatively small role in the overall capability of the aforementioned systems. However, with the dramatic drop in the cost of solid-state memories and the introduction of powerful microprocessors in the 1980's, the role of the *data manager* has now been expanded to incorporate post-processing of the signal processor's output data. Thus, post-processing operations, in addition to the traditional display data management functions, may include:

- For sonar and radar systems
  - Normalization and OR-ing
  - Signal tracking,
  - Localization
  - Data fusion
  - Classification functionality.
- For medical imaging systems

- Image post-processing
- Normalizing operations
- Registration and image fusion.

The above discussion points out that for a next generation DSP system, emphasis should be placed on the degree of interaction between the operator and the system, through an operator-machine interface (OMI) as shown schematically in Figure 7. Through this interface, the operator may selectively proceed with localization, tracking, diagnosis and classification tasks.

A high-level view of the generic requirements and the associated technologies of the data manager of a next generation DSP system reflecting the above concerns could be as shown in Figure 9. The central point of this figure is the operator that controls two kinds of displays (the processed-information and tactical displays) through a continuous interrogation procedure. In response to the operator's request, the units in the *data manager* and *display sub-system* have a continuous interaction including data-flow and requests for processing that include localization, tracking, classification for sonar-radar systems (Chapters 8 and 9 in [42]) and diagnostic images for medical imaging systems (Chapter 7, in [42]).

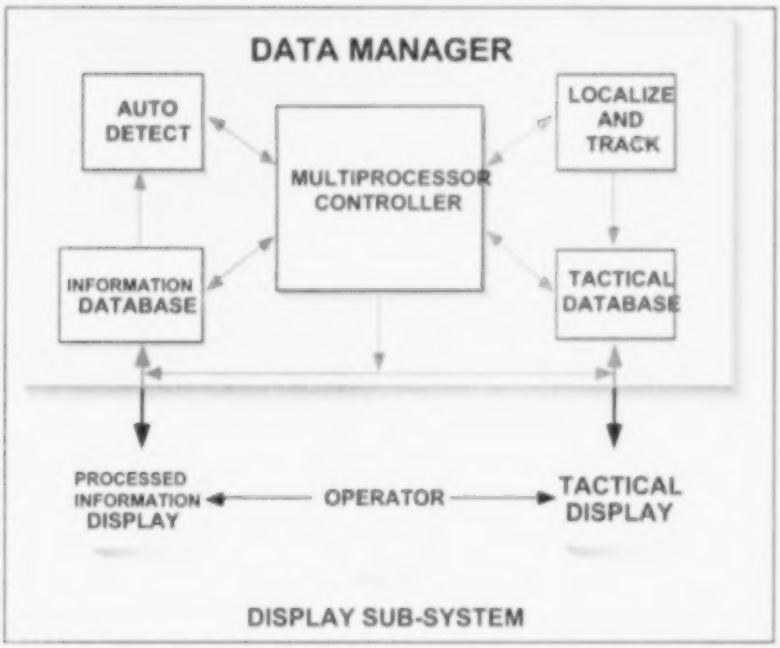


Figure 9. *Schematic diagram for the generic requirements of a data manager for a next generation real time DSP system.*

Even though the processing steps of radar and airborne systems associated with localization, tracking and classification have conceptual similarities with those of a sonar system, the processing techniques that have been successfully applied in airborne systems have not been

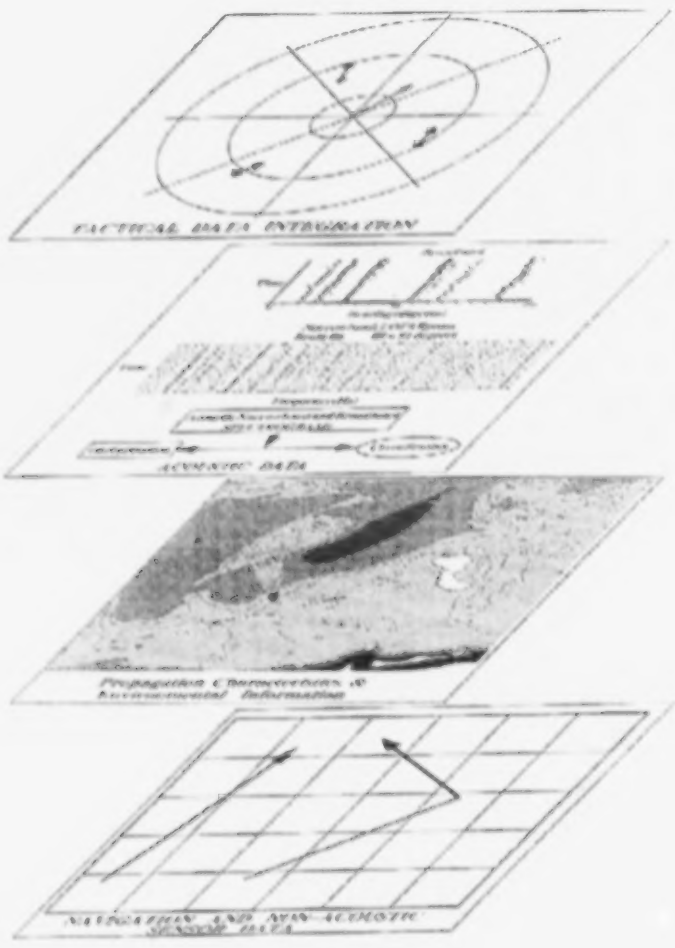
successful with sonar systems. This is a typical situation that indicates how hostile, in terms of signal propagation characteristics, the underwater environment is with respect to the atmospheric environment. However, technologies associated with *data fusion, neural networks, knowledge based systems and automated parameter estimation* will provide solutions to the very difficult operational sonar problem regarding localization, tracking and classification. These issues are discussed in detail in [42, i.e. Chapters 8 and 9]. In particular, Chapter 8 in [42] focuses on target tracking and sensor data processing for active sensors. Although active sensors certainly have an advantage over passive sensors, nevertheless, passive sensors may be prerequisite to some tracking solution concepts, namely passive sonar systems. Thus, Chapter 9 in [42] deals with a class of tracking problems for passive sensors only.

Post-Processing for sonar and radar systems

To provide a better understanding of these differences, let us examine the levels of information required by the data management of sonar, radar and medical imaging systems. Normally, for sonar and radar systems the processing and integration of information from sensor-level to a command and control level includes a few distinct processing steps. Figure 7 shows a simplified overview of the integration of four different levels of information for a sonar or radar system. These levels consist mainly of:

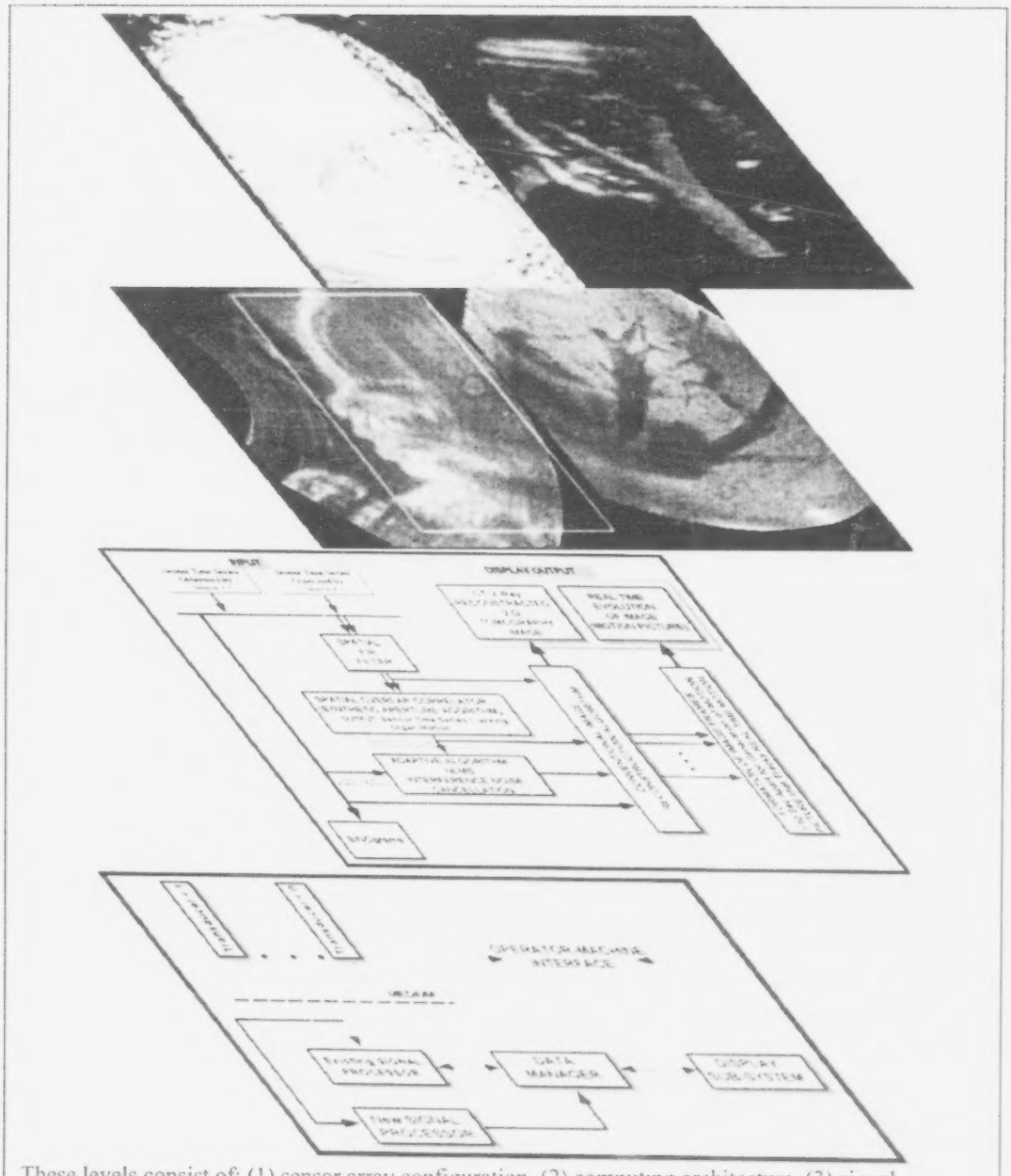
- Navigation and non-sensor array data;
- Environmental information and estimation of propagation characteristics in order to assess the medium's influence on sonar or radar system performance;
- Signal processing of received sensor signals that provide parameter estimation in terms of bearing, range and temporal spectral estimates for detected signals; and
- Signal following (tracking) and localization that monitors the time evolution of a detected signal's estimated parameters.

This last tracking and localization capability [32,33] allows the sonar or radar operator to rapidly assess the data from a multi-sensor system and carry out the processing required to develop an array sensor based tactical picture for integration into the platform level command and control system, as shown later by Figure 15. In order to allow the databases to be searched effectively, a high-performance operator-machine interface (OMI) is required. These interfaces are beginning to draw heavily on modern workstation technology through the use of windows, on-screen menus etc. Large flat panel displays driven by graphic engines which are equally adept at pixel manipulation as they are with 3-D object manipulation will be critical components in future systems. It should be evident by now that the term data manager describes a level of functionality, which is well beyond simple data management. The data manager facility applies technologies ranging from relational databases, neural networks [26], fuzzy systems [27] to expert systems [15,26]. The problems it addresses can be variously characterized as signal, data or information processing.



A simplified overview of integration of different levels of information from sensor level to a command and control level for a sonar or radar system. These levels consist mainly of: (1) navigation, (2) environmental information to access the medium's influence on sonar or radar system performance, (3) signal processing of received array sensor signals that provides parameter estimation in terms of bearing, range and temporal spectral estimates for detected signals, (4) signal following (tracking) and localization of detected targets. (Reprinted with permission of IEEE ©1998).

Figure10. *Integration of Levels of Information for Sonar or Radar System.*



These levels consist of: (1) sensor array configuration, (2) computing architecture, (3) signal processing structure, (4) reconstructed image to assist medical diagnosis.

***Figure 11**. Integration of Levels of Information for Medical Imaging System*

Post-processing for medical imaging systems

Let us examine now the different levels of information to be integrated by the data manager of a medical imaging system. Figure 11 provides a simplified overview of the levels of information to be integrated by a current medical imaging system. These levels include:

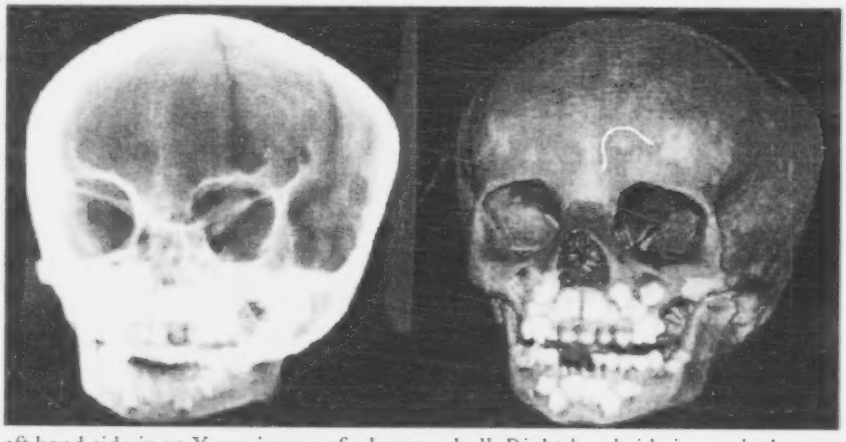
- The system structure in terms of array-sensor configuration and computing architecture;
- Sensor time series signal processing structure;
- Image processing structure; and
- Post-processing for reconstructed image to assist medical diagnosis.

In general, current medical imaging systems include very limited post-processing functionality to enhance the images that may result from mainstream image reconstruction processing. It is anticipated, however, that next generation medical imaging systems will enhance their capabilities in post-processing functionality by including image post-processing algorithms that are discussed in [42, i.e. Chapters 7 and 14].

More specifically, although modern medical imaging modalities such as CT, MRA, MRI, Nuclear Medicine, 3D-Ultrasound and Laser Con-focal Microscopy provide "slices of the body", significant differences exist between the image content of each modality. Post-processing, in this case, is essential with special emphasis on data structures, segmentation, and surface- and volume-based rendering for visualising volumetric data. To address these issues, the first part of Chapter 7 in [42] focuses less in explaining algorithms and rendering techniques, but rather to point out their applicability, benefits, and potential in the medical environment. Moreover, in the second part of Chapter 7 in [42], applications are illustrated from the areas of craniofacial surgery, traumatology, neurosurgery, radiotherapy, and medical education. Furthermore, some new applications of volumetric methods are presented: 3D ultrasound, laser con-focal data sets, and 3D-reconstruction of cardiological datasets, i.e. vessels as well as ventricles. These new volumetric methods are under development and due to their enormous application potential they are expected to be clinically accepted within the next few years.

As an example, Figures 12 and 13 present the results of image enhancement by means of post processing on images that have been acquired by current CT/X-ray and ultrasound systems. The left-hand side image of Figure 12 shows a typical X-ray image of a human skull provided by a current type of CT/X-ray imaging system. The left-hand side image of Figure 12 is the result of post-processing the original X-ray image. It is apparent from these results that the right-hand side image includes imaging details that can be valuable to medical staff in minimizing diagnostic errors and interpretation of image-results. Moreover, this kind of post-processing image functionality may assist in cognitive operations associated with medical diagnostic applications.

Ultrasound medical imaging systems are characterized by poor image resolution capabilities. The three images in Figure 13 (top left and right images, bottom left hand side image) provide pictures of the skull of fetus as provided by a conventional ultrasound imaging system. The bottom left-hand side image of Figure 13, presents the resulting 3-D post-processed image by applying the processing algorithms discussed in [42, i.e. Chapter 7]. The 3-D features and characteristics of the skull of the fetus are very pronounced in this case, although the clarity is not as good as in the case of the CT/X-ray image in Figure 12. Nevertheless, the image resolution characteristics and 3-D features that have been reconstructed in both cases, shown in Figures 12 and 13, provide an example of the potential improvements in the image resolution and cognitive functionality that can be integrated in the next generation medical imaging systems.



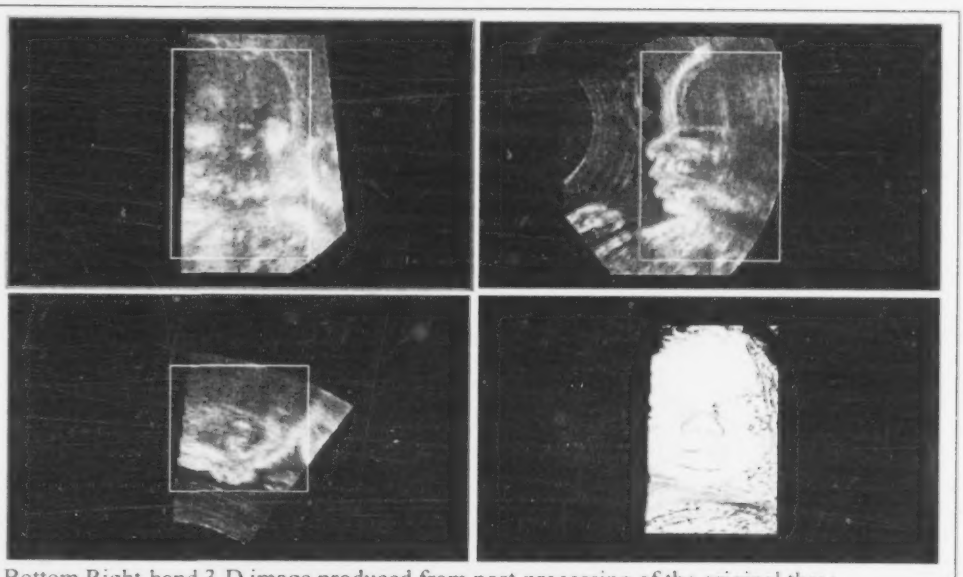
Left hand side is an X-ray image of a human skull. Right-hand side image is the result of image enhancement by means of post-processing the original X-ray image.

Figure 12. *X-Ray Image Enhancement*

Needless to say, the image post-processing functionality of medical imaging systems is directly applicable in sonar and radar applications to reconstruct 2-D and 3-D image details of detected targets. This kind of image reconstruction post-processing capability may improve the difficult classification tasks of sonar and radar systems.

At this point, it is also important to re-emphasize the significant differences existing between the image content and system functionality of the various medical imaging systems mainly in terms of sensor array configuration and signal processing structures. Undoubtedly, a generic approach exploiting the conceptually similar processing functionalities among the various configurations of medical imaging systems will simplify OMI issues that would result in better interpretation of information of diagnostic importance. Moreover, the integration of data fusion functionality in the data manager of medical imaging systems will provide better diagnostic interpretation of the information inherent at the output of the medical imaging systems, by minimizing human errors in terms of interpretation.

Although these issues may appear as exercises of academic interest, it becomes apparent from the above discussion that system advances made in the field of sonar and radar systems may be applicable in medical imaging applications as well.



Bottom Right-hand 3-D image produced from post-processing of the original three ultrasound images of a fetus' skull using conventional medical ultrasound systems. "Courtesy of Prof. G. Sakas, Fraunhofer IDG, Durmstadt, Germany".

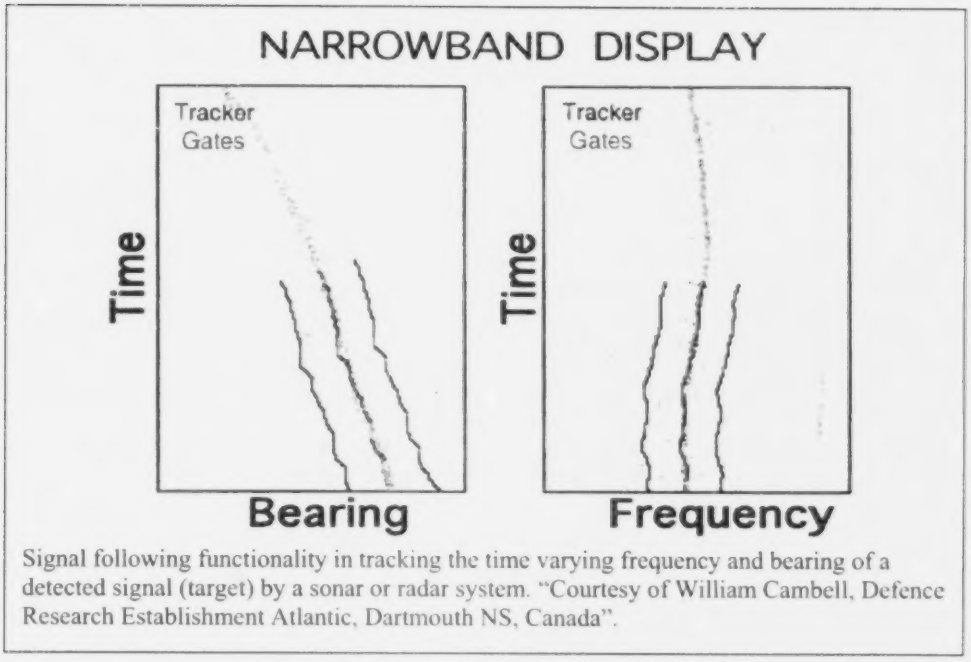
Figure 13. *Ultra-Sound Image Enhancement*

Signal and target tracking and target motion analysis

In sonar, radar and imaging system applications, single sensors or sensor networks are used to collect information on time-varying signal parameters of interest. The individual output data produced by the sensor systems result from complex estimation procedures carried out by the *Signal Processor*. Provided the quantities of interest are related to moving point-source objects or small extended objects (radar targets, for instance), relatively simple statistical models can often be derived from basic physical laws, which describe their temporal behavior and thus define the underlying dynamical system. The formulation of adequate dynamics models, however, may be a difficult task in certain applications. For efficient exploitation of the sensor resources as well as to obtain information not directly provided by the individual sensor reports, appropriate data association and estimation algorithms are required (*sensor data processing*). These techniques result in tracks, i.e. estimates of state trajectories, which statistically represent the quantities or objects considered along with their temporal history. Tracks are initiated, confirmed, maintained, stored, evaluated, fused with other tracks, and displayed by the *tracking system* or *data manager*. The tracking system, however, should be carefully distinguished from the underlying sensor systems, though there may exist close interrelations, such as in the case of multiple target tracking with an agile-beam radar, rising the problem of sensor management.

In contrast to the target tracking via active sensors, discussion in [42, i.e. Chapter 8, Chapter 9] deals with a class of tracking problems that use passive sensors only. In solving tracking problems, active sensors certainly have an advantage over passive sensors. Nevertheless, passive sensors may be prerequisite to some tracking solution concepts. This is the case, for example, whenever active sensors are not feasible from a technical or tactical point of view, as in the case of passive sonar systems deployed by submarines and surveillance naval vessels. An important problem in passive target tracking is the Target Motion Analysis (TMA) problem. The name TMA is normally used for the process of estimating the state of a radiating target from noisy measurements collected by a single passive observer. Typical applications can be found in passive sonar, infrared (IR), or radar tracking systems.

For signal followers, the parameter estimation process for tracking the bearing and frequency of detected signals consists of peak picking in a region of bearing and frequency space sketched by fixed gate sizes at the outputs of the conventional and non-conventional beamformers depicted in Figure 8. Figure 14, provides a schematic interpretation of the signal followers functionality in tracking the time varying frequency and bearing estimates of detected signals in sonar and radar applications. Details about this estimation process can be found in Reference [34] and in Chapters 8 and 9 in [42]. Briefly, in Figure 14, the choice of the gate sizes was based on the observed bearing and frequency fluctuations of a detected signal of interest during the experiments. Parabolic interpolation was used to provide refined bearing estimates [35]. For this investigation, the bearings-only tracking process described in [34] was used as a narrowband tracker, providing unsmoothed time evolution of the bearing estimates to the localization process [32,36].

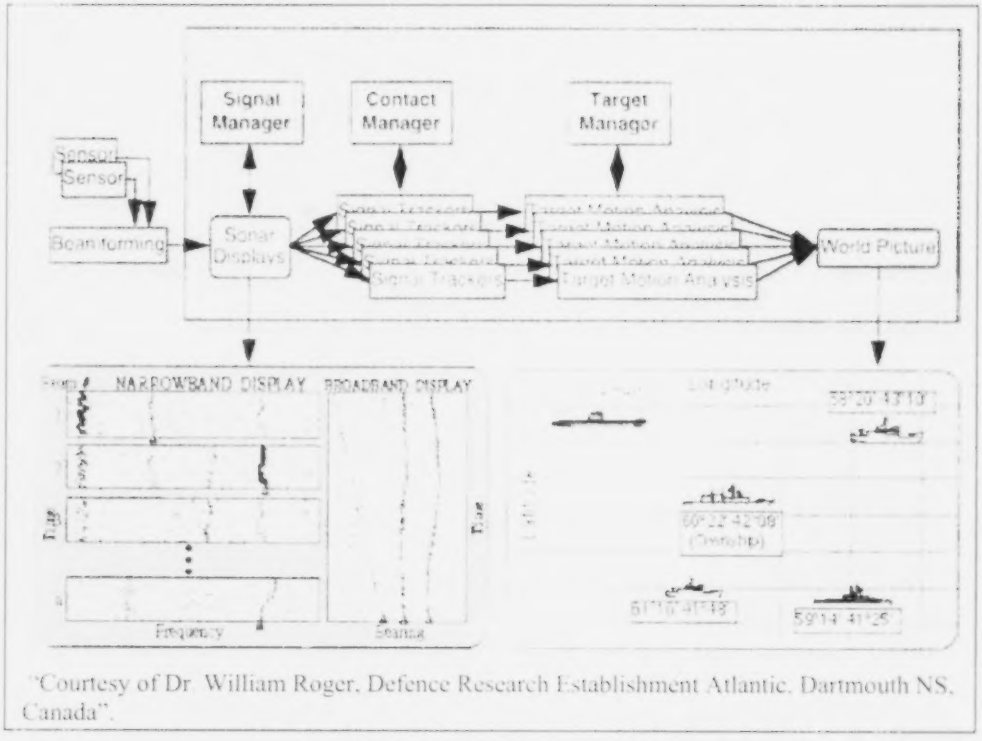


Signal following functionality in tracking the time varying frequency and bearing of a detected signal (target) by a sonar or radar system. "Courtesy of William Cambell, Defence Research Establishment Atlantic, Dartmouth NS, Canada".

Figure 14. *Signal Following Functionality*

Tracking of the time-varying bearing estimates of Figure 14, forms the basic processing step to localize a distant target associated with the bearing estimates. This process is called localization or Target Motion Analysis (TMA), which is discussed in [42, i.e. Chapter 9]. The output results of a TMA process form the tactical display of a sonar or radar system, as shown in Figures 10 and 14. In addition, the temporal-spatial spectral analysis output results and the associated display, (Figures 10 and 14), form the basis for classification and the target identification process for sonar and radar systems. In particular, data fusion of the TMA output results with those of a temporal-spatial spectral analysis output results outline an integration process to define the tactical picture for sonar and radar operations, as shown in Figure 15. For more details, refer to Chapters 8 and 9 in [42], which provide detailed discussions of target tracking and TMA operations for sonar and radar systems [32-36]. The basic operation is to integrate by means of data fusion the signal tracking and localization functionality with the temporal spatial spectral analysis output results of the generic signal processing structure of Figure 8.

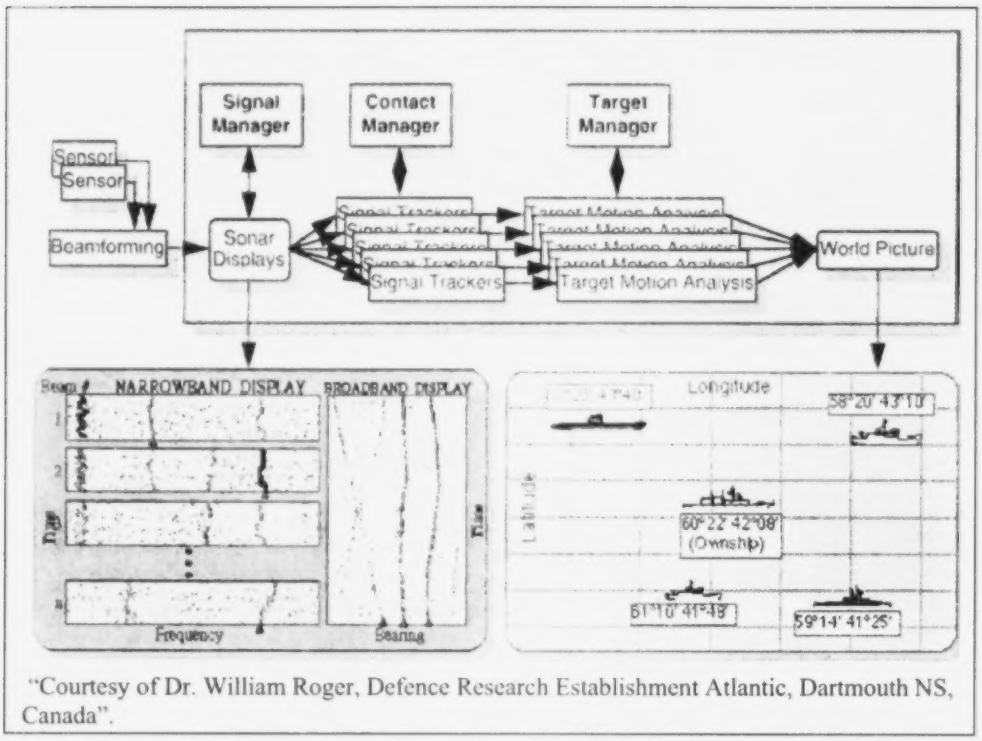
It is apparent from the material presented in this section that for next-generation sonar and radar systems, emphasis should be placed on the degree of interaction between the operator and the system, through an operator-machine interface as shown schematically in Figures 7 and 9. Through this interface, the operator may selectively proceed with localization, tracking and classification tasks, as depicted in Figure 13.



"Courtesy of Dr. William Roger, Defence Research Establishment Atlantic, Dartmouth NS, Canada".

Figure 15. *Formation of a tactical picture for sonar and radar systems.*

In standard Computed Tomography (CT), image reconstruction is performed using projection data that are acquired in a time sequential manner [6,7]. Organ motion (cardiac motion, blood flow, lung motion due to respiration, patient's restlessness etc.) during data acquisition produces artifacts, which appear as a blurring effect in the reconstructed image, and may lead to inaccurate diagnosis [14]. The intuitive solution to this problem is to speed up the data acquisition process, so that the motion effects become negligible. However, faster CT scanners tend to be significantly more costly and, with current x-ray tube technology, the scan times that are required are simply not realizable. Therefore, signal processing algorithms to account for organ motion artifacts are needed. Several mathematical techniques have been proposed as a solution to this problem. These techniques usually assume a simplistic linear model for the motion, such as translational, rotational or linear expansion [14]. Some techniques model the motion as a periodic sequence and take projections at a particular point in the motion cycle to achieve the effect of scanning a stationary object. This is known as a retrospective electrocardiogram (ECG)-gating algorithm and projection data are acquired during 12-15 continuous one-second source rotations while cardiac activity is recorded with an (ECG). Thus, the integration of ECG devices with x-ray CT medical tomography imaging systems becomes a necessity in cardiac imaging applications using x-ray CT and MRI systems. However, the information provided by the ECG devices to select in phase segments of CT projection data can be available by signal trackers that can be applied on the sensor time series of the CT receiving array. This kind of application of signal trackers on CT sensor time series will identify the in-phase



"Courtesy of Dr. William Roger, Defence Research Establishment Atlantic, Dartmouth NS, Canada".

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motion cycles of the heart under a similar configuration as the ECG-gating procedure. Moreover, the application of the signal trackers in cardiac CT imaging systems will eliminate the use of the ECG systems, thus making the medical imaging operations much simpler. These issues are discussed in some detail in [14, i.e. Chapter 16].

It is anticipated, however, that radar, sonar and medical imaging systems will exhibit fundamental differences in their requirements for information post-processing functionality. Furthermore, bridging conceptually similar processing requirements may not always be an optimum approach in addressing practical DSP implementation issues; rather it should be viewed as a source of inspiration for the researchers in their search for creative solutions.

In summarizing this section, the previous premise in DSP system development that "improving the signal processor of a sonar or radar or medical imaging system was synonymous with the development of new signal processing algorithms and faster hardware" has changed. While advances will continue to be made in these areas, future developments in data (contact) management represent one of the most exciting avenues of research in the development of high-performance systems.

In sonar, radar and medical imaging systems, an issue of practical importance is the operational requirement by the operator to be able to rapidly assess numerous images and detected signals in terms of localization, tracking, classification and diagnostic interpretation in order to pass the necessary information up through the chain of command to enable tactical or medical diagnostic decisions to be made in a timely manner. Thus, an assigned task for a *Data Manager* would be to provide the operator with quick and easy access to both the output of the *Signal Processor*, which is called processed data display, and to the tactical display, which will show medical images, localization and tracking information through graphical interaction between the processed data and tactical displays.

Engineering databases

The design and integration of engineering databases in the functionality of a *Data Manager* assists the identification and classification process, as shown schematically in Figure 9. To illustrate the concept of an engineering database, we will consider the land mine identification process, which is an essential functionality in humanitarian demining systems to minimise the false alarm rate. Although there is a lot of information on landmines, often organised in electronic databases, there is nothing like a CAD engineering database. Indeed, most databases serve either documentation purposes or are landmine signatures related to a particular sensor technology. This wealth of information must be collected and organised in such a way so that it can be used online, through the necessary interfaces to the sensorial information, by each one of the future identification systems. Thus, an engineering database is intended to be the common core software applied to all future landmine detection systems [41]. It could be built around a specially engineered database storing all available information on landmines. The underlying idea is to extract the particular features that characterise a particular mine or a class of mine using techniques of cognitive and perceptual sciences and then to define the sensorial information needed to detect these features in typical environments. Such a landmine identification system would not only trigger an alarm for every suspect object but would also reconstruct a comprehensive model of the

target. Successively, it would compare the model to a landmine engineering database deciding or assisting the operator to make a decision as to the nature of the detected object.

A general approach of the engineering database concept and its applicability in the aforementioned DSP systems would assume that an effective engineering database will be a function of the available information on the subjects of interest, such as underwater targets, radar targets and medical diagnostic images. Moreover, the functionality of an engineering database would be highly linked with the multi-sensor data fusion process discussed below.

Multi-sensor data fusion

Data fusion refers to the acquisition, processing and synergistic combination of information from various knowledge sources and sensors to provide a better understanding of the situation under consideration [39]. Classification is an information processing task in which specific entities are mapped to general categories. For example in the detection of land-mines, the fusion of acoustic [41], electromagnetic (EM) and infrared (IR) sensor data are in consideration to provide a better land-mine field picture and minimize the false alarm rates. The discussion of this section has been largely influenced by the work of Kundur and Hatzinakos on "Blind Image Deconvolution" and for more details the reader is referred to [39].

The process of multi-sensor data fusion addresses the issue of system integration of different type of sensors and the problems inherent in attempting to fuse and integrate the resulting data streams into a coherent picture of operational importance. The term integration is used here to describe operations wherein a sensor input may be used independently with respect to other sensor data in structuring an overall solution. ***Fusion*** is used to describe the result of joint analysis of two or more originally distinct data streams.

More specifically, while multi-sensors are more likely to correctly identify positive targets and eliminate false returns, using them effectively will require ***fusing*** the incoming data streams, each of which may have a different character. This task will require solutions to the following engineering problems:

- Correct combination of the multiple data streams in the same context; and
- Processing multiple-signals to eliminate false positives and further refine positive returns.

For example, in humanitarian demining a positive return from a simple metal detector might be combined with a Ground Penetrating Radar (GPR) evaluation resulting in the classification of the target as a spent shell casing, allowing the operator to safely pass by in confidence.

Given a design that can satisfy the above goals, it will then be possible to design and implement computer-assisted or automatic recognition in order to positively identify the nature, position and orientation of a target. Automatic recognition, however, will be pursued by the Engineering Database, as shown in Figure 9.

In Data Fusion, another issue of equal importance is the ability to deal with conflicting data, producing interim results that the algorithm can revise as more data become available. In general, the data interpretation process, as part of the functionality of data fusion, consists briefly of the following stages [39]:

- Low-level data manipulation;
- Extraction of features from the data either using signal processing techniques or physical sensor models;
- Classification of data using techniques such as Bayesian hypothesis testing, Fuzzy Logic, and Neural Networks; and
- Heuristic expert system rules to guide previous levels, make high level control decisions, provide operator guidance, and provide early warnings and diagnostics.

Current R&D projects in this area include the processing of localization and identification of data from various sources, or type of sensors. The systems combine features of modern multi-hypothesis tracking methods and correlation. This approach, to process all available data regarding targets of interest allows the user to extract the maximum amount of information concerning target location from the complex "sea" of available data. Then a correlation algorithm is used to process large volumes of data containing localization and attribute information using multiple hypothesis methods.

In image classification and fusion strategies many inaccuracies often result from attempting to fuse data that exhibit motion-induced blurring or defocusing effects and background noise [37,38]. Compensation for such distortions is inherently sensor-dependent and is non trivial as the distortion is often time varying and unknown. In such cases, blind image processing, which relies on partial only information about the original data and the distorting process, is suitable [39].

In general, multi-sensor data fusion is an evolving subject, which is considered to be highly essential in resolving the sonar, radar detection/classification problem and the diagnostic problem in medical imaging systems. Since a single sensor system with acceptable very low false alarm rate is rarely available, current developments in sonar, radar and medical imaging systems include multi-sensor configurations to minimize the false alarm rates. Then the multi-sensor data fusion process becomes highly essential. Although, data fusion and databases have not been implemented yet in medical imaging systems, undoubtedly, their potential use in this area will be a rapidly evolving R&D subject in the near future. Then system experience in the areas of sonar and radar systems would be a valuable asset in that regard. For medical imaging applications the data and image fusion processes are discussed in detail in Chapter 19 in [42].

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Annexes

Annex A - Program Cost Factor

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Annex I - DOD Capital Programs Analysis

Annex A - Program Cost Factor

Project	Cost ($Million)	Percentage Cost Factor
AH-64D Longbow Apache	$2,664.50	0.0426
EA-6B Prowler	$800.40	0.0128
E-2C Hawkeye	$995.20	0.0159
F/A-18E/F Hornet	$9,446.10	0.1512
B-2 Stealth Bomber	$687.60	0.0110
Radar System (Joint Stars)	$1,237.60	0.0198
UAV Unmanned Aerial Vehicle	$2,516.30	0.0403
ATACMS Army Tactical Missile System	$736.60	0.0118
TOMAHAWK Cruise Missile	$481.90	0.0077
AMRAAM Advanced Medium RangeAir-to-Air Missile	$589.10	0.0094
DDG-51 AEGIS Destroyer	$9,544.80	0.1528
NSSN Virginia Class Submarine	$6,899.60	0.1104
M1A2 Abrams Tank Upgrade	$1,372.70	0.0220
DSCS Defense Satellite CommunicationsSystem (Ground System)	$298.40	0.0048
NAVSTAR Global PositioningSystem	$1,461.40	0.0234
SFW Sensor Fuzed Weapon	$326.80	0.0052
ABL Airborne Lase	$1,459.90	0.0234
MD Missile Defense	$20,959.40	0.3355
Totals:	$62,478.30	1.0000

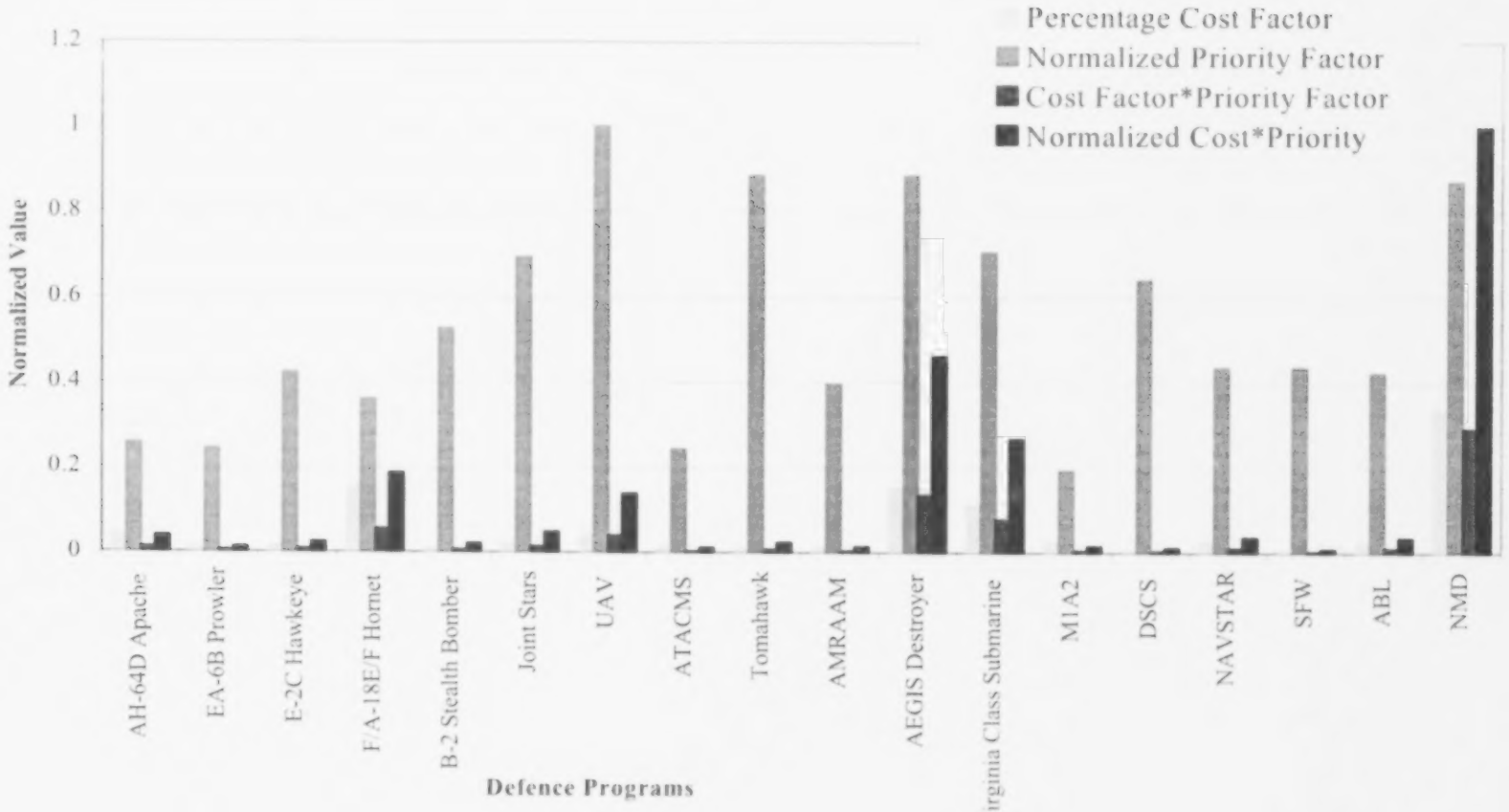
Annex B - Program Rank Summary

Program	Percentage Cost Factor	Normalized Priority Factor	Cost Factor * Priority Factor (Column B * Column C)	Normalized Cost Factor * Priority Factor
AH-64D Apache	0.0426	0.2564	0.0109	0.0373
EA-6B Prowler	0.0128	0.2436	0.0031	0.0107
E-2C Hawkeye	0.0159	0.4231	0.0067	0.0230
F/A-18E/F Hornet	0.1512	0.3590	0.0543	0.1856
B-2 Stealth Bomber	0.0110	0.5256	0.0058	0.0198
Joint Stars	0.0198	0.6923	0.0137	0.0469
UAV	0.0403	1.0000	0.0403	0.1378
ATACMS	0.0118	0.2436	0.0029	0.0098
Tomahawk	0.0077	0.3846	0.0068	0.0233
AMRAAM	0.0094	0.3974	0.0037	0.0128
AEGIS Destroyer	0.1528	0.8846	0.1352	0.4621
Virginia Class Submarine	0.1104	0.7051	0.0778	0.2662
M1A2	0.0220	0.1923	0.0042	0.0145
DSCS	0.0048	0.6410	0.0031	0.0105
NAVSTAR	0.0234	0.4359	0.0102	0.0349
SEW	0.0052	0.4359	0.0023	0.0077
ABL	0.0234	0.4231	0.0099	0.0338
NMD	0.3355	0.8718	0.2925	1.0000

Annex C - Program Priority Factor

Relative Priorities	AH-64D Apache	EA-6B Prowler	E-2C Hawkeye	F/A-18E/F Super Hornet	Stealth B-2A	E-8C Joint Stars	UAV	ATACMS (Army Tactical Missile System)	TOMAHAWK	AMRAAM Advanced Medium Range Air-to-air	DDG-51 AEGIS Destroyer	NSSN Virginia Class Submarine	M1A2 Abrams Tank Upgrade	DSCS (Defense Satellite Communications System)	NAVSTAR Global Positioning System	SFW (Sensor Fused Weapon)	ABL Airborne Laser	National Missile Defense (NMD)
Strategic Deterrence									3		5	9		5	4		7	9
Countering WMD																	9	9
Cooperative Threat Reduction										3								7
Multi-Mission	3			5	3		7	5	7		5	3	4	8	9	8		
Joint	3	1		5	1	5	8	5	7	5	3			8	9	8		
Interoperability	1			4		7	3		2	8	7	3	3	7	9	5		6
Mobility	3	5	5	6	8	9	8	3	9	6	4	5	3				3	
Airlift	5						5		2									
Unmanned/automated systems							9		7	5					3			
Precision, electronic, and non-lethal forms of strike	5	1	3	8	8	3	5		9	4	6	9	5			7		
Extended-range systems and strikes					9	5	7		8		6	9					7	9
Mine Detection and Clearing											5	2						
Sealift											1							
Intelligence/Surveillance/Reconnaissance			7			7	5				3	5		5				8
Stealth (in all its forms, to include undersea forces)					9		8		7		5	9						
Command and Control			9			9		3			3			8				8
Information Operations											2	1		9				3
Force Protection (electronic and platform specific)		9	5			5	4	3			7						7	9
Highly distributed / forced insertion		3	4			4	3		8		7					6		
Accelerated 'Digitization of the Soldier'																		
Compressed operational cycle rates							6											
System Ranking	**20**	**19**	**33**	**28**	**41**	**54**	**78**	**19**	**69**	**31**	**69**	**55**	**15**	**50**	**34**	**34**	**33**	**68**

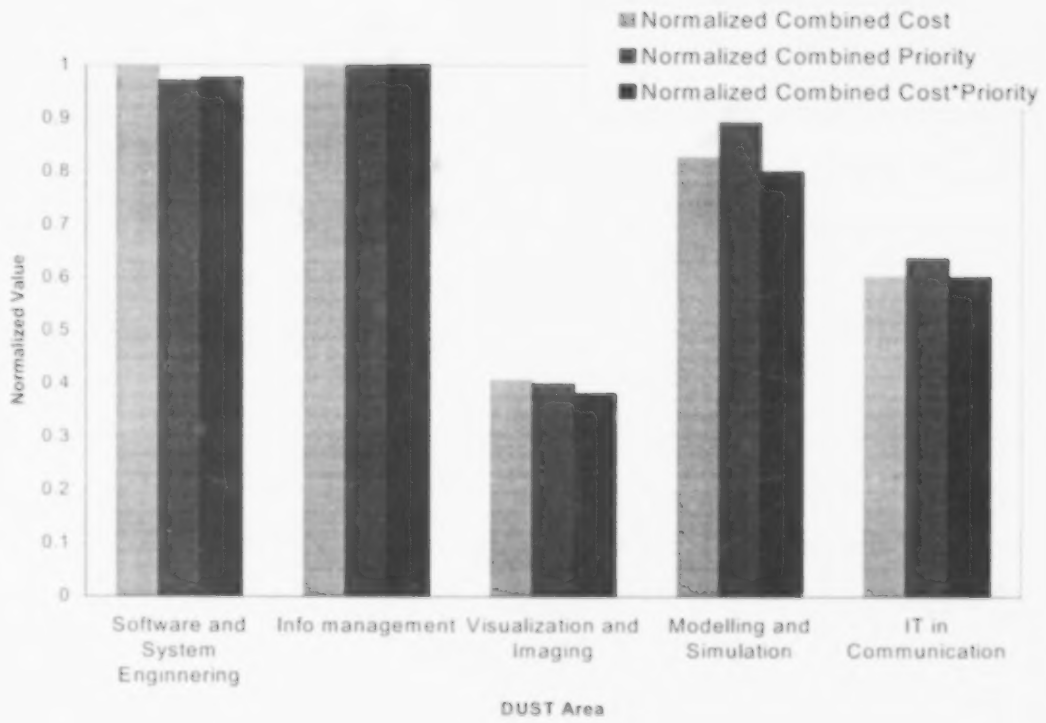
Annex D Cost and Priority Graph



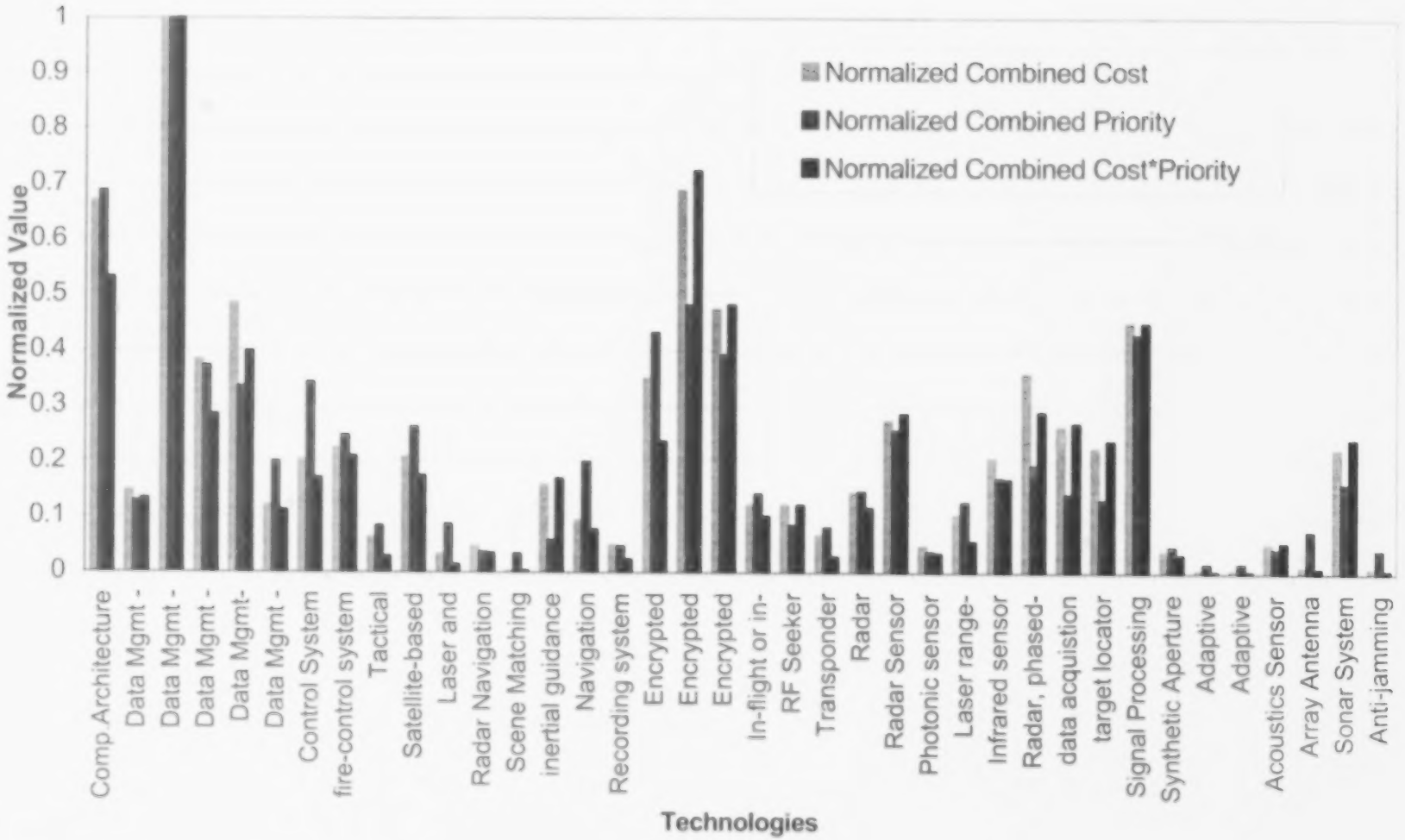
Annex E - DUST Area Rank Summary

DUST Area	Summation of Percentage Cost Factor (from "Combined Analysis" Data Sheet)	Normalized Combined Cost of DUST Area	Summation of Normalized Priority Factor (from "Combined Analysis" Data Sheet)	Normalized Combined Priority of DUST Area	Summation of Individual Cost Factor * Priority Factor (from "Combined Analysis" Data Sheet)	Normalized Combined Cost*Priority of DUST Area
Software and System Engineering	12.0992	1.0000	92.1026	0.9707	8.5896	0.975898394
Information management	12.0742	0.9979	94.8846	1.0000	8.8018	1
Visualization and Imaging	4.9218	0.4068	37.9744	0.4002	3.3638	0.382174043
Modelling and Simulation	10.0106	0.8274	84.6923	0.8926	7.0421	0.800079617
IT in Communication	7.2836	0.6020	60.4744	0.6373	5.2891	0.600909227
MAXIMUM	12.0992	1.0000	94.8846	1.0000	8.8018	1

Annex F – DUST Area Rank Graph



Annex G – Technologies Rank Graph



Annex H - Technical Rank Summary

Technologies	Summation of Percentage Cost Factor (from "Combined Analysis" data sheet)	Normalized Combined Cost of Technologies	Summation of Normalized Priority Factor (from "Combined Analysis" data sheet)	Normalized Combined Priority of Technologies	Summation of Individual Cost Factor * Priority Factor (from "Combined Analysis" data sheet)	Normalized Combined Cost Factor * Priority Factor of Technologies
Computer Architecture	2.1696	0.6689	18.2692	0.6877	1.3766	0.5320
Data Mgmt - General Data Post-Processing	0.4768	0.1470	3.4231	0.1289	0.3443	0.1331
Data Mgmt - Tactical Info Post-Processing	3.2433	1.0000	26.5641	1.0000	2.5876	1.0000
Data Mgmt - General Display Unit	1.2402	0.3824	9.9103	0.3731	0.7391	0.2856
Data Mgmt- Tactical Display Unit	1.5741	0.4853	8.9231	0.3359	1.0327	0.3991
Data Mgmt - Information Database	0.3913	0.1206	5.3077	0.1998	0.2885	0.1115
Control System	0.6561	0.2023	9.1026	0.3427	0.4394	0.1698
Fire-Control System	0.7259	0.2238	6.5641	0.2471	0.5411	0.2091
Tactical Navigation System	0.2047	0.0631	2.2051	0.0830	0.0742	0.0287
Satellite-Based Navigation	0.6716	0.2071	6.9359	0.2611	0.4492	0.1736
Laser and Satellite-Based Navigation	0.1046	0.0323	2.2949	0.0864	0.0338	0.0131
Radar Navigation	0.1530	0.0472	0.9615	0.0362	0.0888	0.0343
Scene Matching Navigation	0.0077	0.0024	0.8846	0.0333	0.0068	0.0026
Inertial Guidance System	0.5095	0.1571	1.5256	0.0574	0.4343	0.1678
Navigation Reference System	0.3032	0.0935	5.2692	0.1984	0.1976	0.0764
Recording System	0.1589	0.0490	1.2436	0.0468	0.0611	0.0236
Encrypted Wireless Communication	1.1350	0.3500	11.4615	0.4315	0.6116	0.2364
Encrypted Wireless Datalink Comms	2.2333	0.6886	12.8077	0.4821	1.8707	0.7229
Encrypted Satellite-Based Communication	1.5377	0.4741	10.4359	0.3929	1.2477	0.4822
In-flight or In-Vessel Communication	0.3951	0.1218	3.7436	0.1409	0.2611	0.1009
RF Seeker	0.3976	0.1226	2.2564	0.0849	0.3131	0.1210
Transponder	0.2162	0.0667	2.1410	0.0806	0.0745	0.0288
Radar Beamformer	0.4650	0.1434	3.8590	0.1453	0.3005	0.1161
Radar Sensor	0.8866	0.2734	6.7692	0.2548	0.7367	0.2847
Photonic sensor	0.1530	0.0472	0.9615	0.0362	0.0888	0.0343
Laser Range-Finder/Designator	0.3344	0.1031	3.3590	0.1264	0.1438	0.0556
Infrared sensor	0.6635	0.2046	4.4872	0.1689	0.4316	0.1668
Radar, Phased-Array Beamformer	1.1618	0.3582	5.1154	0.1926	0.7449	0.2879
Data Acquisition Unit	0.8516	0.2626	3.7179	0.1400	0.6925	0.2676

Target Locator	0.7255	0.2237	3.4744	0.1308	0.6116	0.2363
Signal Processing	1.4582	0.4496	11.3718	0.4281	1.1598	0.4482
Synthetic Aperture	0.1214	0.0374	1.2308	0.0463	0.0836	0.0323
Adaptive Canceller	0.0159	0.0049	0.4231	0.0159	0.0067	0.0026
Adaptive Beamformer	0.0159	0.0049	0.4231	0.0159	0.0067	0.0026
Acoustics Sensor	0.1646	0.0508	1.1282	0.0425	0.1380	0.0533
Array Antenna	0.0359	0.0111	1.9615	0.0738	0.0201	0.0078
Sonar System	0.7216	0.2225	4.2436	0.1597	0.6185	0.2390
Anti-Jamming Mechanism	0.0282	0.0087	1.0769	0.0405	0.0133	0.0051
Column Maximum	3.2433	1.0000	26.5641	1.0000	2.5876	1.0000

Annex I – Program Combined Analysis

Color Code Definition	S	I	M	IT	Matching DUST Areas	Technology Term	Specific Technologies	Major System	Capital Program	Cost ($M)	% Cost Factor	Normalized Priority Factor	Cost Factor - Priority Factor
S-Software and System Engineering	S				Software and System Engineering	Computer Architecture	RPA (Rotorcraft Pilot's Associate) advanced cockpit management system: MIL-STD-1553B databus allied to dual 1750A processors	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
I-Info management	S				Software and System Engineering	Computer Architecture	central digital computer (AN/AYK-14 in ICAP-2 aircraft)	Flight Control and Management system	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
V-Visualization and Imaging	S				Software and System Engineering	Computer Architecture	IBM AN/ASQ-133 or AN/ASQ-155 solid-state digital computer is coupled to A-6E's radar, inertial and Doppler navigational equipment, communications and AFCS	Flight Control and Management system	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
M-Modeling and Simulation	S				Software and System Engineering	Computer Architecture	Fairchild signal data converter accepts analogue input data from up to 60 sensors, converting data to a digital output that is fed into nav/attack system computer	Flight Control and Management system	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
IT-IT in Communication	S				Software and System Engineering	Computer Architecture	mission computer processor	Flight Control and Management system	E-2C Hawkeye	990.2	0.0159	0.4231	0.0067
	S				Software and System Engineering	Computer Architecture	Mission Computer Upgrade(MCU) available to Hawkeye2000: based on Raytheon's Model 940(a modification of Digital Equipment Corporation 2100 Model A500/MP processing system)	Flight Control and Management system	E-2C Hawkeye	990.2	0.0159	0.4231	0.0067
	S				Software and System Engineering	Computer Architecture	AN/ARA-50 UHF ADF, AN/ASW-25B ACLS; BAE Systems standard central air data computer	Flight Control and Management system	E-2C Hawkeye	990.2	0.0159	0.4231	0.0067
	S				Software and System Engineering	Computer Architecture	AN/ARC-158 UHF data/link	Flight Control and Management system	E-2C Hawkeye	990.2	0.0159	0.4231	0.0067

	S					Software and System Engineering	Computer Architecture	Litton OL-77/ASQ computer programmer (L-304) with Lockheed Martin enhanced high-speed processor	Flight Control and Management system	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
	S					Software and System Engineering	Computer Architecture	AN/ARQ-34 HF datalink and JTIDS Class 2 HP terminal	Flight Control and Management system	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
	S					Software and System Engineering	Computer Architecture	AN/AYK-14 digital computers	Flight Control and Management system	F/A-18E/F Super Hornet	9.446.1	0.1512	0.3590	0.0543
	S					Software and System Engineering	Computer Architecture	If upgraded, DMV-179 single board computers and PMC-642 fibre channel network interface mo	Flight Control and Management system	F/A-18E/F Super Hornet	9.446.1	0.1512	0.3590	0.0543
	S					Software and System Engineering	Computer Architecture	Link 16 NATO-compatible datalink	Flight Control and Management system	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
	S					Software and System Engineering	Computer Architecture	secure, stealthy SATCOM downlink capability will use broadband Advanced Extremely High Frequency (EHF) radios, replace current low data rate UHF SATCOMs	Flight Control and Management system	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
	S					Software and System Engineering	Computer Architecture	replacement Centre Instrument Display (CID) upgrade and improvements to the In-Flight Replanning Unit (IFRU	Flight Control and Management system	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
	S					Software and System Engineering	Computer Architecture	very high-speed processors, each capable of over 600 Mops	Flight Control and Management system	E-8C Joint Stars	1,237.6	0.0198	0.6923	0.0137
	S					Software and System Engineering	Computer Architecture	Multi-function information distribution system (MIDS) datalink	Communication System	F/A-18E/F Super Hornet	9.446.1	0.1512	0.3590	0.0543
	S					Software and System Engineering	Computer Architecture	TADS (target acquisition and designation sight) optical relay tube	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S					Software and System Engineering	Computer Architecture	C 4516C hybrid computer, two core memories each of 32 kbytes, and a solid-state memory of 128 kbytes	Flight control and Management System	TOMAHAWK	481.9	0.0077	0.8846	0.0068
	S					Software and System Engineering	Computer Architecture	digital computer	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
	S					Software and System Engineering	Computer Architecture	AN/SLX-1 MSTRAP(Multi-sensor torpedo recognition and alertment processor) with easy-to-read display provides info, signal processing, and controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions.	Sensor Systems	[illegible]	[illegible]	0.1528	0.8846	0.1352
	S					Software and System Engineering	Computer Architecture	SQQ-28 for LAMPS processor datalink	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352

	S					Software and System Engineering	Computer Architecture	Libera/PA-TD-MMO processor equipped with (L-3M) with Lockheed Martin enhanced high-speed processor	Flight Control and Management system			0.0159	0.4233	0.0067
	S					Software and System Engineering	Computer Architecture	MIL-STD-1553B data bus and IEEE-1394 data bus	Flight Control and Management system			0.0159	0.4233	0.0067
	S					Software and System Engineering	Computer Architecture	MIL-STD-1553B data bus	Flight Control and Management system			0.0062	0.0961	0.0043
	S					Software and System Engineering	Computer Architecture	Fully-qualified, DSP-based single board computers and IEEE-1394 fibre optical network interfaces	Flight Control and Management system			0.1512	0.0961	0.0043
	S					Software and System Engineering	Computer Architecture	Link 16 NATO compatible datalink	Flight Control and Management system			0.0110	0.5236	0.0058
	S					Software and System Engineering	Computer Architecture	Inmarsat, Iridium, Skybridge SATCOM downlink capability with low broadband Advanced Extremely High Frequency (EHF) radios, Intrepid current low data rate UHF SATCOMs	Flight Control and Management system			0.0110	0.5236	0.0058
	S					Software and System Engineering	Computer Architecture	Management Centric Instrument Display (CID) upgrade and improvements to the In-Flight Refueling test (IFR)	Flight Control and Management system			0.0110	0.5236	0.0058
	S					Software and System Engineering	Computer Architecture	very high-speed processors, each capable of over 200 Mips	Flight Control and Management system			0.0098	0.6923	0.0137
	S					Software and System Engineering	Computer Architecture	Multi-function information distribution system (MIDS) datalink	Communication System			0.1512	0.4961	0.0543
	S					Software and System Engineering	Computer Architecture	TADS (target acquisition and designation sight) pilot night vision sensor	Sensor Systems			0.0420	0.2564	0.0769
	S					Software and System Engineering	Computer Architecture	CC-45 mil. hybrid computer, two core memories each of 32 kilobytes, and a solid-state memory of 128 kbytes	Flight control and Management System			0.0077	0.8846	0.0068
	S					Software and System Engineering	Computer Architecture	Digital ceramic	Navgation			0.0077	0.8846	0.0068
	S					Software and System Engineering	Computer Architecture	AN/ALQ-7 MS (HAP) Multi-sensor system, navigation and aircraft processor	Sensor Systems			0.1512	0.0961	0.052
	S					Software and System Engineering	Computer Architecture	8052 28 kb CAMPS processor daughter	Flight control and Management System			0.1512	0.0961	0.052

	S						Software and System Engineering	Computer Architecture	Mk 116 ASWCS is a mainframe computer system which is designed to provide battle planning, threat evaluation, tactical data processing, contact management, target engagement processing, and weapon fire control. With integral switchboard or data converter	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
	S						Software and System Engineering	Computer Architecture	AN/UYQ-70 advanced display systems include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning.	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
	S						Software and System Engineering	Computer Architecture	LAMPS MK III datalink system provides full duplex, secure and highly reliable communications between airborne and shipboard platforms	Communication system	[illegible]	[illegible]	0.1528	0.8846	0.1352
	S						Software and System Engineering	Computer Architecture	Signals from the photonic and advanced ASTECS ESM (the AN/BLQ-10) sensors will be relayed to the Combat Control System Mk 2 and AN/BSY-2 command system via a fibre optic link and presented on flat panel displays	Sensor Systems	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S						Software and System Engineering	Computer Architecture	CCSM(Command and Control System Module): include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, farbic optics network, tactic	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S						Software and System Engineering	Computer Architecture	AN/UYQ-70 ADS(Advanced display System), supported by COTS and modified COTS modules open system architecture. uses a 100 MHz HP 743 single-board 6U VME processor with 64 Mbytes of error-correcting RAM which can be expanded to 256 Mbytes. ROM is user-defi	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S						Software and System Engineering	Computer Architecture	new asynchronous databus	communication system	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S						Software and System Engineering	Computer Architecture	TAC-X computer technology and asynchronous transfer mode networking technology.	communication system	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S						Software and System Engineering	Computer Architecture	fire-control system includes the laser range-finder, full-solution solid-state digital computer and stabilised day/thermal night sight.	Flight control and Management System	M1A2 Abrams Tank Upgrade	[illegible]	0.0220	0.1923	0.0042

	S					Software and System Engineering	Computer Architecture	fire-control computer hardware consists of an electronics unit and a separate data entry and test panel.	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
	S					Software and System Engineering	Computer Architecture	Improved Commander's Weapon Station (ICWS)	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
	S					Software and System Engineering	Computer Architecture	FOS; a mission data processing subsystem, utilising ruggedised commercial hardware, hosts the BMC4I software and supports the distribution of information between the weapon system segments over the Local Area Network (LAN).	Flight control and Management System	ABL Airborne Laser	1,459.9	0.0234	0.4231	0.0099
	S					Software and System Engineering	Computer Architecture	HF, VHF, UHF and AFSATCOM connectivity for both voice and data (Link 16 and TIBS), fully supporting the TMD FOS.	Communication System	ABL Airborne Laser	1,459.9	0.0234	0.4231	0.0099
		I				Info management	Data Management - General Data Post-Processing	RPA advanced data fusion and an advanced pilotage system	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I				Info management	Data Management - General Data Post-Processing	all-raster symbology generator processes TV data from IR and other sensors, superimposes symbology	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I				Info management	Data Management - General Data Post-Processing	IFF	Flight Control and Management system	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
		I				Info management	Data Management - General Data Post-Processing	Battery power, Frequency management, performance monitoring, and communications diagnostics	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
		I				Info management	Data Management - General Data Post-Processing	21 modes including terrain-following and terrain-avoidance	Sensor Systems	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
		I				Info management	Data Management - General Data Post-Processing	30 MHz microprocessor deals with all navigation, autopilot, radar, fuzing and built-in test functions	Flight control and Management System	AMRAAM Advanced Medium Range Air-to-air Missile	589.1	0.0094	0.3974	0.0037

	S						Software and System Engineering	Computer Architecture	Mk 116 ASWCS is a mainframe computer system which is designed to provide battle planning, threat evaluation, tactical data processing, contact management, target engagement processing, and weapon fire control. With integral switchboard or data converter	Flight control and Management System			0.1528	0.8846	0.1352
	S						Software and System Engineering	Computer Architecture	AN/UYQ-70 advanced display systems include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System			0.1528	0.8846	0.1352
	S						Software and System Engineering	Computer Architecture	LAMPS Mk III datalink system provides full duplex secure and highly reliable communications between airborne and shipboard platforms	Communication system			0.1528	0.8846	0.1352
	S						Software and System Engineering	Computer Architecture	Signals from the photonic and advanced ASTECS ESM (the AN/BLQ-10) sensors will be relayed to the Combat Control System Mk 2 and AN/BSY-2 command system via a fibre optic link and presented on flat panel displays	Sensor Systems			0.1104	0.7051	0.0778
	S						Software and System Engineering	Computer Architecture	CCSM(Command and Control System Module) include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, fiber optics network, tactic	Flight control and Management System			0.1104	0.7051	0.0778
	S						Software and System Engineering	Computer Architecture	AN/UYQ-70 ADS(Advanced display System), supported by COTS and modified COTS modules, open system architecture, uses a 100 MHz HP 743 single-board 6U VME processor with 64 Mbytes of error-correcting RAM which can be expanded to 256 Mbytes. ROM is user-def	Flight control and Management System			0.1104	0.7051	0.0778
	S						Software and System Engineering	Computer Architecture	new asynchronous database	communication system			0.1104	0.7051	0.0778
	S						Software and System Engineering	Computer Architecture	TAC-X computer technology and asynchronous transfer mode networking technology	communication system			0.1104	0.7051	0.0778
	S						Software and System Engineering	Computer Architecture	fire-control system, includes the laser range finder, solid-state digital computer and stabilized day-thermal sight unit	Flight control and Management System			0.0220	0.1923	0.0042

	S					Software and System Engineering	Computer Architecture	The control computer hardware consists of an electronics unit and a separate data entry and test panel	Flight control and Management System			0.0220	0.1923	0.0042
	S					Software and System Engineering	Computer Architecture	Improved Commander's Weapon Station (ICWS)	Flight control and Management System			0.0220	0.1923	0.0042
	S					Software and System Engineering	Computer Architecture	FOS, a mission data processing subsystem utilising ruggedised commercial hardware, hosts the BMC4I software and supports the distribution of information between the weapon system segments over the Local Area Network (LAN)	Flight control and Management System			0.0234	0.4231	0.0099
	S					Software and System Engineering	Computer Architecture	HF, VHF, UHF and AFSATCOM connectivity for both voice and data (Link 16 and TIBS), fully supporting the TMD FOS	Communication System			0.0234	0.4231	0.0099
		I				Info management	Data Management - General Data Post-Processing	RPA advanced data fusion and an advanced postage system	Flight Control and Management system	AH-64D Apache	2,668.5	0.0426	0.2564	0.0109
		I				Info management	Data Management - General Data Post-Processing	Jet-taste symbology generator processes TV data from IR and other sensors, superimposes symbology	Flight Control and Management system	AH-64D Apache	2,668.5	0.0426	0.2564	0.0109
		I				Info management	Data Management - General Data Post-Processing	IFF	Flight Control and Management system			0.0159	0.4231	0.0067
		I				Info management	Data Management - General Data Post-Processing	Battery power, Frequency management, performance monitoring, and communications diagnostics	Communication System	[illegible] AN/ARC-[illegible]	[illegible]	0.0198	0.6923	0.0137
		I				Info management	Data Management - General Data Post-Processing	21 modes including terrain-following and terrain-avoidance	Sensor Systems	[illegible]		0.0110	0.5256	0.0058
		I				Info management	Data Management - General Data Post-Processing	30 MHz microprocessor deals with air navigation, autopilot, radar, fuzing and built-in-test functions	Flight control and Management System	AN/AAQ-[illegible] Advanced Common Navigation Suite (ACNS) [illegible]	[illegible]	0.0094	0.3974	0.0037

		1				Info management	Data Management - General Data Post-Processing	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
		1				Info management	Data Management - Tactical Information Post-processing	JTIDS tactical software and upgraded engines form core of Update Development Program (Groups I and II)	Flight Control and Management system	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
		1				Info management	Data Management - Tactical Information Post-processing	Joint Tactical Information Distribution System (JTIDS): terminals are carried in the aircraft to establish TADIL-J interoperability with other systems equipped with JTIDS terminals	Flight Control and Management system	E-8C Joint Stars	1,237.6	0.0198	0.6923	0.0137
		1				Info management	Data Management - Tactical Information Post-processing	perform the data processing and display functions for tens of thousands of targets and C³I operation	Flight Control and Management system	E-8C Joint Stars	1,237.6	0.0198	0.6923	0.0137
		1				Info management	Data Management - Tactical Information Post-processing	TADS (target acquisition and designation sight): targets can be tracked manually or automatically for autonomous attack with gun, rockets or Hellfire missiles	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		1				Info management	Data Management - Tactical Information Post-processing	PNVS (pilot night vision sensor): thermal imaging for nap-of-the-earth flight to, from and within battle area at night or in adverse daytime weather, at altitudes low enough to avoid detection	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		1				Info management	Data Management - Tactical Information Post-processing	AN/APQ-181 low-probability-of-intercept (LPI) J-band covert strike radar	Sensor Systems	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
		1				Info management	Data Management - Tactical Information Post-processing	New radar modes including Ground Moving-Target Indication (GMTI)	Sensor Systems	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058

		1				Info management	Data Management - Tactical Information Post-processing	4× zoom magnification available on radar picture	Sensor Systems	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
		1				Info management	Data Management - Tactical Information Post-processing	advanced multimode radar system	Sensor Systems	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
		1				Info management	Data Management - Tactical Information Post-processing	Litton AN/ALR-67 radar warning receiver: provides simultaneous ground mapping; identification, tracking, and range-finding of fixed or moving targets; and terrain-clearance or terrain-following manoeuvres	Sensor Systems	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
		1				Info management	Data Management - Tactical Information Post-processing	Brilliant Anti-Armor Technology (BAT) : capable to seek and attack armoured targets by using high-precision passive sensors: target search by acoustic probes on the wingtips and infra-red sensors in the nose	Sensor Systems	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029
		1				Info management	Data Management - Tactical Information Post-processing	an imaging dual-colour infra-red and millimetric wave radar seeker head	Sensor Systems	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029
		1				Info management	Data Management - Tactical Information Post-processing	Low Cost Autonomous Attack System (LOCAAS) guided by a laser radar (LADAR) and intended for defeating critical ground targets. The LADAR seeker acts as a high-resolution range measurement device determining absolute range to each pixel in the image and ge	Sensor Systems	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029
		1				Info management	Data Management - Tactical Information Post-processing	target discrimination and identification software	Flight control and Management System	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029
		1				Info management	Data Management - Tactical Information Post-processing	fire-control software	Flight control and Management System	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029

		1					Info management	Data Management - General Data Post-Processing	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information; process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20,999.4	0.3355	0.6718	0.2925
		1					Info management	Data Management - Tactical Information Post-processing	JTIDS tactical software and upgraded engines form core of Update Development Program (Groups I and II)	Flight Control and Management system	E-3C Sentinel	9,000	0.0159	0.4231	0.0067
		1					Info management	Data Management - Tactical Information Post-processing	Joint Tactical Information Distribution System (JTIDS): terminals are carried in the aircraft to establish TADIL-J interoperability with other systems equipped with JTIDS terminals	Flight Control and Management system	E-8C Joint Stars	19,237.6	0.0198	0.6923	0.0137
		1					Info management	Data Management - Tactical Information Post-processing	perform the data processing and display functions for tens of thousands of targets and C3 operation	Flight Control and Management system	E-8C Joint Stars	27,1	0.0198	0.6923	0.0137
		1					Info management	Data Management - Tactical Information Post-processing	TADS (target acquisition and designation sight): targets can be tracked manually or automatically for autonomous attack with gun, rockets or Hellfire missiles	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		1					Info management	Data Management - Tactical Information Post-processing	PNVS (pilot night vision sensor): thermal imaging for nap-of-the-earth flight to, from and within battle area at night or in adverse daytime weather, at altitudes low enough to avoid detection	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		1					Info management	Data Management - Tactical Information Post-processing	AN/APQ-181 low-probability-of-intercept (LPI) J-band covert strike radar	Sensor Systems	B-2A Spirit (Stealth Bomber)	497.4	0.0110	0.5256	0.0058
		1					Info management	Data Management - Tactical Information Post-processing	New radar modes including Ground Moving-Target Indication (GMTI)	Sensor Systems	B-2A Spirit (Stealth Bomber)	497.4	0.0110	0.5256	0.0058

		I					Info management	Data Management - Tactical Information Post processing	4+ zoom magnification available on radar picture	Sensor Systems	[illegible]	[illegible]	0.0110	0.5256	0.0058
		I					Info management	Data Management - Tactical Information Post-processing	advanced multimode radar system	Sensor Systems	Joint Stars (E-8C), designated AN/APY-3	1,237 kg	0.0198	0.6923	0.0137
		I					Info management	Data Management - Tactical Information Post-processing	Litton AN/ALR-67 radar warning receiver, provides simultaneous ground mapping, identification, tracking, and range-finding of fixed or moving targets, and terrain-clearance or terrain-following manoeuvres	Sensor Systems	EA-6B Prowler and the AEW Hawkeye	500 kg	0.0128	0.2436	0.0031
		I					Info management	Data Management - Tactical Information Post-processing	Brilliant Anti-Armor Technology (BAT) - capable to seek and attack armoured targets by using high-precision passive sensors: target search by acoustic probes on the wingtips and infra-red sensors in the nose	Sensor Systems	[illegible]	[illegible]	0.0118	0.2436	0.0029
		I					Info management	Data Management - Tactical Information Post-processing	an imaging dual-colour infra-red and millimetric wave radar seeker head	Sensor Systems	[illegible]	[illegible]	0.0118	0.2436	0.0029
		I					Info management	Data Management - Tactical Information Post-processing	Low Cost Autonomous Attack System (LOCAAS) guided by a laser radar (LADAR) and intended for defeating critical ground targets. The LADAR seeker acts as a high-resolution range measurement device determining absolute range to each pixel in the image and ge	Sensor Systems	[illegible]	[illegible]	0.0118	0.2436	0.0029
		I					Info management	Data Management - Tactical Information Post processing	target discrimination and identification software	Flight control and Management System	[illegible]	[illegible]	0.0118	0.2436	0.0029
		I					Info management	Data Management - Tactical Information Post processing	fire-control software	Flight control and Management System	[illegible]	[illegible]	0.0118	0.2436	0.0029

		I				Info management	Data Management - Tactical Information Post-processing	processor use video information in a correlation mode, supplies final guidance corrections in the terminal phase of the cruise missile's flight to its target	Sensor Systems	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I				Info management	Data Management - Tactical Information Post-processing	ESM system (Passive identification/Direction-finding Equipment or PI/DE) for passive identification and direction-finding of potential targets	Flight control and Management System	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I				Info management	Data Management - Tactical Information Post-processing	in shore-based sites or bases, Theater Mission Planning System (TMPS) , each having a theatre planning package and a rapid strike planning system. The theatre planning package plans various routes to prospective targets around the world using maps and da	Flight control and Management System	TOMAHAWK	481.9	0.0077	0.8846	0.0060
		I				Info management	Data Management - Tactical Information Post-processing	Digital Scene Matching Area Correlator (DSMAC)	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I				Info management	Data Management - Tactical Information Post-processing	CCD Camera which uses an 18 mm second-generation image intensifier for night or bad weather operations	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I				Info management	Data Management - Tactical Information Post-processing	30 MHz microprocessor deals with all navigation, autopilot, radar, fuzing and built-in test functions	Flight control and Management System	AMRAAM Advanced Medium-Range Air-to-air Missile	589.1	0.0094	0.3974	0.0037
		I				Info management	Data Management - Tactical Information Post-processing	command link receiver antennas, which receive guidance updates on target position and manoeuvre from the launch aircraft	Communication System	AMRAAM Advanced Medium-Range Air-to-air Missile	589.1	0.0094	0.3974	0.0037
		I				Info management	Data Management - Tactical Information Post-processing	Gould/Raytheon/GE SQQ-89(V)6: combines SQS-53C, bow-mounted, active search and attack with SQR-19B passive towed array (TACTAS) low frequency	Sensor Systems	[illegible]	1144.2	0.1528	0.8846	0.1352

		I				Info management	Data Management - Tactical Information Post-processing	AN/SLX-1 MSTRAP(Multi-sensor torpedo recognition and alertment processor) with easy-to-read display: provides info, signal processing, and controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions.	Sensor Systems	[illegible]	[illegible]	0.1528	0.8846	0.1352
		I				Info management	Data Management - Tactical Information Post-processing	NTDS Mod 5 with Links 4A, 11, 14 and 16 (from DDG 72) and being back fitted	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
		I				Info management	Data Management - Tactical Information Post-processing	SQQ-28 for LAMPS processor datalink	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
		I				Info management	Data Management - Tactical Information Post-processing	TADIX B Tactical Information Exchange System (from DDG 72	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
		I				Info management	Data Management - Tactical Information Post-processing	Fire control: Three Raytheon/RCA SPG-62 [Ref 10], I/J-band	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
		I				Info management	Data Management - Tactical Information Post-processing	Mk 116 ASWCS is a mainframe computer system which is designed to provide battle planning, threat evaluation, tactical data processing, contact management, target engagement processing, and weapon fire control. With integral switchboard or data converter	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
		I				Info management	Data Management - Tactical Information Post-processing	AN/UYQ-70 advanced display systems include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
		I				Info management	Data Management - Tactical Information	Tacan(Tactical air navigation): URN 25 [Ref 11] (FF Mk XII AIMS UPX-29	Navigation	[illegible]	[illegible]	0.1528	0.8846	0.1352

		1					Data Management	Data Management - Tactical Information Fusion Processing	Combined use of data information in a correlation mode, enables the optimum compromise in the terminal phase of the mission to track and engage a target	Sensor Systems					
		1					Data Management	Data Management - Tactical Information Fusion Processing	A CAI system (Fusion Aircraft Control System - Fire up Equipment) or TCDE (to provide identification and direction finding of potential targets	Flight control and Management System					
		1					Data Management	Data Management - Tactical Information Fusion Processing	In-cockpit based Use of Mission Planner System (UMPS) - each having a theatre planning package and a part of an planning system. The theatre planning package each operator loads up mission specific targets, aircraft and payload config data, and so	Flight control and Management System					
		1					Data Management	Data Management - Tactical Information Fusion Processing	Digital Scene Matching Area Correlator (DSMAC)	Navigation					
		1					Data Management	Data Management - Tactical Information Fusion Processing	CCD Camera which uses an IR and second generation image intensifier for night or bad weather operations	Navigation					
		1					Data Management	Data Management - Tactical Information Fusion Processing	A CAI system (Fusion Aircraft Control System - automatic radar Tuning and Lock-on Sensitivity	Flight control and Management System					
		1					Data Management	Data Management - Tactical Information Fusion Processing	Communication System, antennae, which receive guidance updates on target position and commands from the aircraft	Communication System					
		1					Data Management	Data Management - Tactical Information Fusion Processing	Cloud Displacer (LB-1062/AVQ-26 Pave Tack) Pod, now mounted on the nose and utilizes a Hughes AN/APQ-180 electronic steered array (ESA) for low frequency	Sensor Systems					

		1					Info management	Data Management - Tactical information Post-processing	AN SLX-1 MILHAM(Multi-sensor towards recognition and sea bord processor) will supply an fused display, provides info. signal processing, and control as necessary to detect, classify and to allow missile breakaway. It associates, corrects and carries functions.	Sensor Systems			0.1528	0.8846	0.1352
		1					Info management	Data Management - Tactical information Post-processing	NTDS Mod 5 will have 48 TTY/KB and 16 from UYK-7(2) and beyond have fitted.	Flight control and Management System			0.1528	0.8846	0.1352
		1					Info management	Data Management - Tactical information Post-processing	SQQ-28 for LAMPS processor data link	Flight control and Management System			0.1528	0.8846	0.1352
		1					Info management	Data Management - Tactical information Post-processing	TADIX B Tactical Information Exchange System (from DDG 2)	Flight control and Management System			0.1528	0.8846	0.1352
		1					Info management	Data Management - Tactical information Post-processing	Fire control: Three Raytheon/RCA SPG-62 [Ref 10]. I/J-band	Flight control and Management System			0.1528	0.8846	0.1352
		1					Info management	Data Management - Tactical information Post-processing	Mk 116 ASWCS is a mainframe computer system which is designed to provide battle planning, threat evaluation, tactical data processing, contact management, target engagement processing, and weapon fire control. With integral switchboard or data converter	Flight control and Management System			0.1528	0.8846	0.1352
		1					Info management	Data Management - Tactical information Post-processing	AN UYQ-70 advanced display systems include new internal secure and non-secure communication solutions, fiber-optic based Link Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead-Reckoning	Flight control and Management System			0.1528	0.8846	0.1352
		1					Info management	Data Management - Tactical information	Tacan(Tactical air navigation) URN 25 [Ref 11]. It is Mk XII AIMS UPX-29	Navigation			0.1528	0.8846	0.1352

								Post-processing							
		I					Info management	Data Management - Tactical Information Post-processing	Signals from the photonic and advanced ASTECS ESM (the AN/BLQ-10) sensors will be relayed to the Combat Control System Mk 2 and AN/BSY-2 command system via a fibre optic link and presented on flat panel displays	Sensor Systems	[illegible]	[illegible]	0.1104	0.7051	0.0778
		I					Info management	Data Management - Tactical Information Post-processing	Signals from the photonic and advanced ASTECS ESM (the AN/BLQ-10) sensors will be relayed to the Combat Control System Mk 2 and AN/BSY-2 command system via a fibre optic link and presented on flat panel displays	Sensor Systems	[illegible]	[illegible]	0.1104	0.7051	0.0778
		I					Info management	Data Management - Tactical Information Post-processing	CCSM(Command and Control System Module): include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, farbic optics network, tactic	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
		I					Info management	Data Management - Tactical Information Post-processing	AN/UYQ-70 ADS(Advanced display System), supported by COTS and modified COTS modules open system architecture: uses a 100 MHz HP 743 single-board 6U VME processor with 64 Mbytes of error-correcting RAM which can be expanded to 256 Mbytes. ROM is user-defi	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
		I					Info management	Data Management - Tactical Information Post-processing	infra-red Thermal Imaging System (TIS) has been developed by the Raytheon Systems Company and produces an image by sensing the small difference in heat radiated by the objects in view The detected energy is converted into electrical signals which are dis	Sensor Systems	M1A2 Abrams Tank Upgrade	1.372 7	0.0220	0.1923	0.0042
		I					Info management	Data Management - Tactical Information Post-processing	externally side-mounted IR sensor, which is reported to be highly resistant to countermeasures, detects the target, works out the aim-point and triggers the warhead	Sensor Systems			0.0052	0.4359	0.0023

		I				Info management	Data Management - Tactical Information Post-processing	TILL(Tracking ILluminator Laser) is the heart of the beam control/fire control system, projecting rapid, powerful pulses of light on a small section of a boosting target missile. The light will be reflected back to an extremely sensitive camera. The refl	Sensor Systems	ABL Airborne Laser	1,459.0	0.0234	0.4231	0.0099
		I				Info management	Data Management - Tactical Information Post-processing	nose-mounted turret, which will house a 1.5 m telescope intended to focus laser energy onto the target and collect return signals and image data	Sensor Systems	ABL Airborne Laser	1,459.0	0.0234	0.4231	0.0099
		I				Info management	Data Management - Tactical Information Post-processing	BMC4I segment provides surveillance, communication, planning, and the central command and control of the ABL weapon system	Flight control and Management System	ABL Airborne Laser	1,459.0	0.0234	0.4231	0.0099
		I				Info management	Data Management - Tactical Information Post-processing	X-band/ Ground based radar (XBR): high frequency and advanced radar signal processing technology to improve target resolution, which permits the radar to more accurately discriminate between closely-spaced objects, perform tracking, discrimination, and ki	Sensor Systems	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
		I				Info management	Data Management - Tactical Information Post-processing	Upgraded Early Warning Radar (UEWR): phased-array surveillance radars used to detect and track ballistic missiles targeted at the United States. Software upgrades to these existing early warning radars would provide the capability to support NMD surveilla	Sensor Systems	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
		I				Info management	Data Management - Tactical Information Post-processing	BMC2 (Battle Management, Command and Control) unit, provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	flat-panel, colour, active matrix LCD multi-purpose displays (MPDs	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	manprint' cockpit with large displays	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109

		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	processed data sent to CRT and helmet-mounted display	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	integrated helmet and display sighting system (HADSS): PNVS imagery displayed on monocle in front of one of pilot's eyes; flight information including airspeed, altitude and heading is superimposed on this imagery to simplify piloting	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Kaiser AN/AVA-1 multi-mode display	Flight Control and Management system	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Barco Display Systems to supply graphics controllers with radar display capability and colour flat panel displays	Flight Control and Management system	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	BAE Systems/Hazeltine AN/APA-172 control indicator group with Lockheed Martin enhanced (colour) main display units (EMDU)	Flight Control and Management system	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	AN/APA-172 will be replaced by L-3 Communications flat panel display screen during 2000-07	Flight Control and Management system	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	(5 in) square monochrome displays and will have monochrome programmable LCD in place of F/A-18C engine/fuel display	Flight Control and Management system	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Flight, engine, sensor and systems information presented on nine-tube EFIS display	Flight Control and Management system	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	advanced computers and 18 operator display stations	Flight Control and Management system	E-8C Joint Stars	1,237.6	0.0198	0.6923	0.0137
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	high-resolution colour graphic and touchscreen tabular displays	Flight Control and Management system	E-8C Joint Stars	1,237.6	0.0198	0.6923	0.0137
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	6-channel visual system	Flight Control and Management system	UAV	2,516.3	0.0403	1.0000	0.0403

		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	PNVS imagery displayed on monocle in front of one of pilot's eyes: integrated helmet and display sighting system (HADSS): flight information including airspeed, altitude and heading is superimposed on this imagery to simplify piloting	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	AN/APS-145 advanced radar processing system (ARPS): fully automated/optimised overland detection	Sensor Systems	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	AN/UYQ-70 advanced display systems:include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System	DDG 51 AEGIS Destroyer	9,844.3	0.1528	0.8846	0.1352
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	AN/UYQ-70 ADS(Advanced display System), supported by COTS and modified COTS modules open system architecture: uses a 100 MHz HP 743 single-board 6U VME processor with 64 Mbytes of error-correcting RAM which can be expanded to 256 Mbytes. ROM is user-defi	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	infra-red Thermal Imaging System (TIS) has been developed by the Raytheon Systems Company and produces an image by sensing the small difference in heat radiated by the objects in view. The detected energy is converted into electrical signals which are dis	Sensor Systems	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Commander's Integrated Display (CID)	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Driver's Integrated Display (DID)	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Gunner's Control and Display Panel (GCDP)	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Inter-Vehicular Information System (IVIS),	Communication System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042

		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	PNVS imagery displayed on monocle in front of one of pilot's eyes. Integrated helmet and display sighting system (HADSS): flight information including airspeed, altitude and heading is superimposed on this imagery to simplify piloting	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	AN/APS-145 advanced radar processing system (ARPS): fully automated/optimised overland detection	Sensor Systems	[illegible]	[illegible]	0.0159	0.4231	0.0067
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	AN/UYQ-70 advanced display systems include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System			0.1528	0.8846	0.1352
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	AN/UYQ-70 ADS(Advanced display System), supported by COTS and modified COTS modules, open system architecture, uses a 100 MHz HP 743 single-board 6U VME processor with 64 Mbytes of error-correcting RAM which can be expanded to 256 Mbytes. ROM is user-defi	Flight control and Management System			0.1104	0.7051	0.0778
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Infra-red Thermal Imaging System (TIS) has been developed by the Raytheon Systems Company and produces an image by sensing the small difference in heat radiated by the objects in view. The detected energy is converted into electrical signals which are dis	Sensor Systems	[illegible]	[illegible]	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Commander's Integrated Display (CID)	Flight control and Management System			0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Driver's Integrated Display (DID)	Flight control and Management System	[illegible]	[illegible]	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Gunner's Control and Display Panel (GCDP)	Flight control and Management System	[illegible]	[illegible]	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	Inter-Vehicular Information System (IVIS).	Communication System	[illegible]	[illegible]	0.0220	0.1923	0.0042

		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	AN/APN-209 radar altimeter video display unit	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	256 targets on tactical situation display	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	(3 × 5 in) touch-panel LCD upfront display and 159 mm (6¼ in) square colour LCD tactical situation display	Flight Control and Management system	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	for strike misssion plane (10 × 8 in) AMLCD	Flight Control and Management system	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	Teledyne Systems AN/ASN-123 navigation system with digital display group	Navigation	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	FLIR (Forward-Looking Infra-Red) system: TRAM system acquire target on radar screen	Sensor Systems	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	miniature solid-state Charge-Coupled Device (CCD) TV camera: digital scene-matching area-correlator guidance system	Sensor Systems	TOMAHAWK	481.9	0.0128	0.8846	0.0113
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	AN/SLX-1 MSTRAP(Multi-sensor torpedo recognition and alertment processor) with easy-to-read display: provides info, signal processing, and controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions.	Sensor Systems			0.1528	0.8846	0.1352

		I	V			Info management, Visualization and Imaging	Data Management - General Display Unit	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	AN/APN-209 radar altimeter video display unit	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	256 targets on tactical situation display	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	(3 × 5 in) touch-panel LCD upfront display and 159 mm (6¼ in) square colour LCD tactical situation display	Flight Control and Management system	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	for strike misssion plane (10 × 8 in) AMLCD	Flight Control and Management system	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	Teledyne Systems AN/ASN-123 navigation system with digital display group	Navigation	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	FLIR (Forward-Looking Infra-Red) system: TRAM system acquire target on radar screen	Sensor Systems	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	miniature solid-state Charge-Coupled Device (CCD) TV camera: digital scene-matching area-correlator guidance system	Sensor Systems	TOMAHAWK	481.9	0.0128	0.8846	0.0113
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	AN/SLX-1 MSTRAP(Multi-sensor torpedo recognition and alertment processor) with easy-to-read display: provides info, signal processing, and controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions,	Sensor Systems	[illegible]	[illegible]	0.1528	0.8846	0.1352

		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	Mk 116 ASWCS directly interfaces with shipboard acoustic sensors (typically AN/SQS-53, AN/SQR-19 and AN/SQQ-28), radar, ESM(entry monitor system), and receives offboard sensor data via datalink.	Sensor Systems	[illegible]	[illegible]	0.1528	0.8846	0.1352
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	AN/UYQ-70 advanced display systems include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	CCSM(Command and Control System Module): include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, farbic optics network, tactic	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	AN/UYQ-70 ADS(Advanced display System), supported by COTS and modified COTS modules open system architecture: uses a 100 MHz HP 743 single-board 6U VME processor with 64 Mbytes of error-correcting RAM which can be expanded to 256 Mbytes. ROM is user-defi	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	infra-red Thermal Imaging System (TIS) has been developed by the Raytheon Systems Company and produces an image by sensing the small difference in heat radiated by the objects in view. The detected energy is converted into electrical signals which are dis	Sensor Systems	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	Commander's Integrated Display (CID)	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	Driver's Integrated Display (DID)	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	Gunner's Control and Display Panel (GCDP)	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042

		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	Inter-Vehicular Information System (IVIS),	Communication System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	display of all parameters controlling the automatic sequencing of the weapon system	Flight control and Management System	ABL Airborne Laser	1,3[illegible]	0.0234	0.4231	0.0099
		I	V			Info management, Visualization and Imaging	Data Management - Tactical Display Unit	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
		I				Info management	Data Management - Information Database	real-world, textured visual database imagery	Flight Control and Management system	UAV	2,516.3	0.0403	1.0000	0.0403
		I				Info management	Data Management - Information Database	IFF	Flight Control and Management system	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
		I				Info management	Data Management - Information Database	User-friendly interactive software is used and the databases include flight simulation, image processing, colour graphics, analyses of defensive systems and photogrammetry.	Flight control and Management System	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I				Info management	Data Management - Information Database	Raytheon digital 3-D AN/MPQ-64 Ground-Based Sensor (Sentinel) search and track radar with built-in IFF system	Sensor Systems	AMRAAM Advanced Medium Range Air-to-air Missile	589.1	0.0094	0.3974	0.0037
		I				Info management	Data Management - Information Database	30 MHz microprocessor deals with all navigation, autopilot, radar, fuzing and built-in test functions	Flight control and Management System	AMRAAM Advanced Medium Range Air-to-air Missile	589.1	0.0094	0.3974	0.0037
		I				Info management	Data Management - Information Database	AN/SLX-1 MSTRAP(Multi-sensor torpedo recognition and alertment processor) with easy-to-read display: provides info, signal processing, and controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions.	Sensor Systems	DDG-51 AEGIS Destroyer	9,544.8	0.1528	0.8846	0.1352
		I				Info management	Data Management - Information Database	Joint Maritime Command Information System (to allow the 'Virginia' class to interoperate with other ships, submarines, aircraft, ground units and command activities	communication system	Virginia Class Submarine	6,[illegible]	0.1104	0.7051	0.0778

		I				Info management	Data Management - Information Database	Inter-Vehicular Information System (IVIS).	Communication System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
		I				Info management	Data Management - Information Database	FOS; a mission data processing subsystem, utilising ruggedised commercial hardware, hosts the BMC4I software and supports the distribution of information between the weapon system segments over the Local Area Network (LAN).	Flight control and Management System	ABL Airborne Laser	1,459.9	0.0234	0.4231	0.0099
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	lightweight flight management computer (Hamilton Sundstrand) :digital autostabiliser	Flight Control and Management system	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	advanced control indicator set (ACIS)	Flight Control and Management system	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	BAE Systems/Hazeltine AN/APA-172 control indicator group with Lockheed Martin enhanced (colour) main display units (EMDU)	Flight Control and Management system	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	simulated portable UAV control box	Flight Control and Management system	UAV	2,516.3	0.0403	1.0000	0.0403

		I	V			Info management. Visualization and Imaging	Data Management - Tactical Display Unit	Inter-Vehicular Information System (IVIS).	Communication System	[illegible]	[illegible]	0.0220	0.1923	0.0042
		I	V			Info management. Visualization and Imaging	Data Management - Tactical Display Unit	display of all parameters controlling the automatic sequencing of the weapon system	Flight control and Management System			0.0234	0.4231	0.0099
		I	V			Info management. Visualization and Imaging	Data Management - Tactical Display Unit	BMC2 (Battle Management, Command and Control) unit; provide extensive decision support systems, battle management system, battle management display, and situation awareness information; process the information and communicate target assignments to interce	Flight control and Management System	[illegible]	[illegible]	0.3355	0.8718	0.2925
		I				Info management	Data Management - Information Database	real-world, textured visual database imagery	Flight Control and Management system	[illegible]	[illegible]	0.0403	1.0000	0.0403
		I				Info management	Data Management - Information Database	IFF	Flight Control and Management system	[illegible]	[illegible]	0.0159	0.4231	0.0067
		I				Info management	Data Management - Information Database	User-friendly interactive software is used and the databases include flight simulation, image processing, colour graphics, analyses of defensive systems and photogrammetry.	Flight control and Management System	[illegible]	[illegible]	0.0077	0.8846	0.0068
		I				Info management	Data Management - Information Database	Raytheon digital 3-D AN/MPQ-64 Ground-Based Sensor (Sentinel) search and track radar with built-in IFF system	Sensor Systems	[illegible]	[illegible]	0.0094	0.3974	0.0037
		I				Info management	Data Management - Information Database	30 MHz microprocessor deals with all navigation, autopilot, radar, fuzing and built-in test functions.	Flight control and Management System	[illegible]	[illegible]	0.0094	0.3974	0.0037
		I				Info management	Data Management - Information Database	AN/SLX-1 MSTRAP(Multi-sensor torpedo recognition and alertment processor) with easy-to-read display; provides info, signal processing, and controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions.	Sensor Systems			0.1528	0.8846	0.1352
		I				Info management	Data Management - Information Database	Joint Maritime Command Information System (to allow the 'Virginia' class to interoperate with other ships, submarines, aircraft, ground units and command activities	communication system			0.1104	0.7051	0.0778

		I				Info management	Data Management - Information Database	Inter-Vehicular Information System (IVIS).	Communication System	[illegible]	[illegible]	0.0220	0.1923	0.0042
		I				Info management	Data Management - Information Database	FOS, a mission data processing subsystem utilising rugged/sed commercial hardware, hosts the BMC4I software and supports the distribution of information between the weapon system segments over the Local Area Network (LAN)	Flight control and Management System	[illegible]	[illegible]	0.0234	0.4231	0.0099
	S		V	M		Software and System Engineering, Modeling and Simulation, Visualization and Imaging	Control System	lightweight flight management computer (Hamilton Sundstrand) digital autostabiliser	Flight Control and Management system	AH-64D Apache	2.666 5	0.0426	0.2564	0.0109
	S		V	M		Software and System Engineering, Modeling and Simulation, Visualization and Imaging	Control System	advanced control indicator set (ACIS)	Flight Control and Management system	[illegible]	[illegible]	0.0159	0.4231	0.0067
	S		V	M		Software and System Engineering, Modeling and Simulation, Visualization and Imaging	Control System	BAE Systems/Raytheon AN/APA-172 control indicator group with Lockheed Martin enhanced (colour) multi-display units (EMDU)	Flight Control and Management system	[illegible]	[illegible]	0.0159	0.4231	0.0067
	S		V	M		Software and System Engineering, Modeling and Simulation, Visualization and Imaging	Control System	simulated portable UAV control box	Flight Control and Management system	[illegible]	[illegible]	0.0403	1.0000	0.0403

	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	AN/ARN-89B ADF(auto direction-finder)	Navigation	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	Battery power, Frequency management, performance monitoring, and communications diagnostics	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	TADS (target acquisition and designation sight): with CPG (Control Processing Group) as primary operator	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	AN/APS-145 advanced radar processing system (ARPS): fully automated/optimised overland detection	Sensor Systems	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	in shore-based sites or bases, Theater Mission Planning System (TMPS) : each having a theatre planning package and a rapid strike planning system. The theatre planning package plans various routes to prospective targets around the world using maps and da	Flight control and Management System	TOMAHAWK	481.9	0.0077	0.8846	0.0068

	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	receive commands from, and be monitored by, the launch platform through a UHF satellite communications system and a video datalink system, compatible with the airborne AN/AAW-13, to alter target assignments and to conduct damage assessment	Communication System	TOMAHAWK	481.9	0.0077	0.8846	0.0068
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	30 MHz microprocessor deals with all navigation, autopilot, radar, fuzing and built-in test functions	Flight control and Management System	AMRAAM Advanced Medium Range Airr-to-air Missile	589.1	0.0094	0.3974	0.0037
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	fire-control system includes the laser range-finder, full-solution solid-state digital computer and stabilised day/thermal night sight.	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	network controllers direct SATCOM control functions over terrestrial teletype circuits in each earth terminal	Flight Control and Management System	DSCS (Defense Satellite Communications System)	298.4	0.0048	0.6410	0.0031
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	Actual control is accomplished by the Air Force Satellite Control Facility (AFSCF), an element of the Space Command. The AFSCF consists of a worldwide network of Remote Tracking Stations (RTS) used to track, receive telemetry and command DSCS operational	Flight Control and Management System	DSCS (Defense Satellite Communications System)	298.4	0.0048	0.6410	0.0031

	S		V	M	Software and System Engineering; Modelling and Simulation; Visualization and imaging	Control System	AN/ARN-89B ADF (auto direction finder)	Navigation	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S		V	M	Software and System Engineering; Modelling and Simulation; Visualization and imaging	Control System	Battery power, Frequency management, performance monitoring, and communications diagnostics	Communication System	Joint Stars (E-8C) designated AN/APY-3	1,237.9	0.0198	0.6923	0.0137
	S		V	M	Software and System Engineering; Modelling and Simulation; Visualization and imaging	Control System	TADS (target acquisition and designation sight) with CPG (Control Processing Group) as primary operator	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S		V	M	Software and System Engineering; Modelling and Simulation; Visualization and imaging	Control System	AN/APS-145 advanced radar processing system (ARPS): fully automated optimised overland detection	Sensor Systems			0.0159	0.4231	0.0067
	S		V	M	Software and System Engineering; Modelling and Simulation; Visualization and imaging	Control System	in shore-based sites or bases. Theater Mission Planning System (TMPS)... each having a theatre planning package and a rapid strike planning system. The theatre planning package plans various routes to prospective targets around the world using maps and da	Flight control and Management System	F/A-18A/B/C/D	957.3	0.0077	0.8846	0.0068

	S		V	M	Software and System Engineering, Modeling and Simulation, Visualization and Imaging	Control System	Receive commands from, and be monitored by, the launch platform through a UHF satellite communications system and a video datalink system, compatible with the airborne AN/AAW-13, to alter target assignments and to conduct damage assessment	Communication System	[illegible]	[illegible]	0.0077	0.8846	0.0068
	S		V	M	Software and System Engineering, Modeling and Simulation, Visualization and Imaging	Control System	30 MHz microprocessor deals with all navigation, autopilot, radar, fuzing and built-in test functions	Flight control and Management System	AMRAAM Advanced Medium Range Air-to-air Missile	989	0.0094	0.3974	0.0037
	S		V	M	Software and System Engineering, Modeling and Simulation, Visualization and Imaging	Control System	fire control system includes the laser range finder, full-solution solid-state digital computer and stabilised day/thermal night sight	Flight control and Management System	[illegible]	562	0.0220	0.1923	0.0042
	S		V	M	Software and System Engineering, Modeling and Simulation, Visualization and Imaging	Control System	network controllers direct SATCOM control functions over terrestrial teletype circuits in each earth terminal	Flight Control and Management System	[illegible]	[illegible]	0.0048	0.6410	0.0031
	S		V	M	Software and System Engineering, Modeling and Simulation, Visualization and Imaging	Control System	Active control is accomplished by the Air Force Satellite Control Facility (AFSCF), an element of the Space Command. The AFSCF consists of a worldwide network of Remote Tracking Stations (RTS) used to track, receive telemetry and command DSCS operational	Flight Control and Management System	[illegible]	[illegible]	0.0048	0.6410	0.0031

	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	Wind Corrected Munitions Dispensers (WCMD)	Flight control and Management System	[illegible]	[illegible]	0.0052	0.4359	0.0023
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	A beacon laser is then used to obtain atmospheric correction signals for the high-energy laser wavefront	Sensor Systems	[illegible]	[illegible]	0.0234	0.4231	0.0099
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	Control System	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	fire-control software	Flight control and Management System	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	The rapid strike planning system incorporates visual data from airborne, and possibly spaceborne, reconnaissance. Once the data has been processed in tape form it is transmitted through UHF satellite link to the ships where the data is stored, then upload	Flight control and Management System	TOMAHAWK	481.9	0.0077	0.8846	0.0068

	S		V	M	Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	AN/SLX-1 MSTRAP(Multi-sensor torpedo recognition and alertment processor) with easy-to-read display: provides info, signal processing, and controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions,	Sensor Systems	DDG-51 AEGIS Destroyer	9,544.8	0.1528	0.8846	0.1352
	S		V	M	Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	Fire control: Three Raytheon/RCA SPG-62 [Ref 10]; I/J-band	Flight control and Management System	DDG-51 AEGIS Destroyer	9,544.8	0.1528	0.8846	0.1352
	S		V	M	Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	Mk 116 ASWCS is a mainframe computer system which is designed to provide battle planning, threat evaluation, tactical data processing, contact management, target engagement processing, and weapon fire control. With integral switchboard or data converter	Flight control and Management System	DDG-51 AEGIS Destroyer	9,544.8	0.1528	0.8846	0.1352
	S		V	M	Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	CCSM(Command and Control System Module) include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, farbic optics network, tactic	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S		V	M	Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	fire-control system includes the laser range-finder, full-solution solid-state digital computer and stabilised day/thermal night sight.	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042

	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	Fire Control Electronics Unit (FCEU)	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	TILL(Tracking ILluminator Laser) is the heart of the beam control/fire control system, projecting rapid, powerful pulses of light on a small section of a boosting target missile. The light will be reflected back to an extremely sensitive camera. The refl	Sensor Systems	ABL Airborne Laser	1,459.9	0.0234	0.4231	0.0099
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	beam illuminator would then be tracked by a camera, and adjusted by the fire-control system to put the high-energy laser weapon onto the selected aimpoint on the target after adjusting for jitter and beam distortions	Flight control and Management System	ABL Airborne Laser	1,459.9	0.0234	0.4231	0.0099
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	Beam Control/Fire-Control (BC/FC) hardware and software and for the infra-red search and track system	Flight control and Management System	ABL Airborne Laser	1,459.9	0.0234	0.4231	0.0099
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	BMC4I segment provides surveillance, communication, planning, and the central command and control of the ABL weapon system	Flight control and Management System	ABL Airborne Laser	1,459.9	0.0234	0.4231	0.0099
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Tactical Navigation System	Teledyne Systems AN/ASN-123 navigation system with digital display group	Navigation	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031

		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Tactical Navigation System	Smiths/Harris tactical aircraft moving map capability (TAMMAC)	Navigation	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Tactical Navigation System	GPS-Aided Targeting System (GATS)	Sensor Systems	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Tactical Navigation System	DSQ-28 frequency-agile, active radar seeker	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Tactical Navigation System	Position/Navigation System (POS/NAV)	Navigation	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	GPS	Navigation	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	GPS	Navigation	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	GPS	Navigation	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543

	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	Fire Control Electronics Unit (FCEU)	Flight control and Management System	[MTAS Avionics Suite Upgrade]	1372.7	0.0220	0.1923	0.0042
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	TILL(Tracking ILluminator Laser) is the heart of the beam control/fire control system, projecting rapid, powerful pulses of light on a small section of a boosting target missile. The light will be reflected back to an extremely sensitive camera. The refl	Sensor Systems			0.0234	0.4231	0.0099
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	beam illuminator would then be tracked by a camera, and adjusted by the fire-control system to put the high-energy laser weapon onto the selected aimpoint on the target after adjusting for jitter and beam distortions	Flight control and Management System			0.0234	0.4231	0.0099
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	Beam Control/Fire-Control (BC/FC) hardware and software and for the infra-red search and track system	Flight control and Management System			0.0234	0.4231	0.0099
	S		V	M		Software and System Enginnering, Modelling and Simulation, Visualization and imaging	fire-control system	BMC4I segment provides surveillance, communication, planning, and the central command and control of the ABL weapon system	Flight control and Management System			0.0234	0.4231	0.0099
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Tactical Navigation System	Teledyne Systems AN/ASN-123 navigation system with digital display group	Navigation	[EA-6B Prowler(Based on A-6E model)]	820.4	0.0128	0.2436	0.0031

		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Tactical Navigation System	Smiths/Harris tactical aircraft moving map capability (TAMMAC)	Navigation	F/A-18E/F Super Hornet	9.446.1	0.1512	0.3590	0.0543
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Tactical Navigation System	GPS-Aided Targeting System (GATS)	Sensor Systems	[illegible]	[illegible]	0.0110	0.5256	0.0058
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Tactical Navigation System	DSQ 28 frequency-agile, active radar seeker	Navigation	[illegible]	[illegible]	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Tactical Navigation System	Position/Navigation System (POS/NAV)	Navigation	[illegible]	[illegible]	0.0220	0.1923	0.0042
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	GPS	Navigation	AH-64D Apache	2.666.5	0.0426	0.2564	0.0109
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	GPS	Navigation	[illegible]	[illegible]	0.0159	0.4231	0.0067
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	GPS	Navigation	[illegible]	[illegible]	0.1512	0.3590	0.0543

		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	GPS	Navigation	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	inertial guidance system and GPS receiver for in-flight position updates to improve accuracy	Navigation	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	in shore-based sites or bases, Theater Mission Planning System (TMPS) : each having a theatre planning package and a rapid strike planning system. The theatre planning package plans various routes to prospective targets around the world using maps and da	Flight control and Management System	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	TAINS (Tercom-Aided Inertial Navigation System)/ Tercom (Terrain contour matching) and Inertial Navigation System (INS)	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	GPS receiver with new five-element array antenna which, together with the DSMAC, is claimed to provide a 250 per cent improvement in CEP	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	Surface search: Norden/DRS SPS-67(V)3 [Ref 9]; G-band.	Sensor Systems	DDG-51 AEGIS Destroyer	9,544.9	0.1528	0.8846	0.1352
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Satellite-based navigation	Raytheon SPS-64(V)9; I-band.	Navigation	DDG-51 AEGIS Destroyer	9,544.9	0.1528	0.8846	0.1352

		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Satellite-based navigation	CCSM(Command and Control System Module): include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, farbic optics network, tactic	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Laser and Satellite-based Navigation	INS	Navigation	AH-64D Apache	2 666.5	0.0426	0.2564	0.0109
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Laser and Satellite-based Navigation	AN/ASN-92 CAINS carrier aircraft inertial navigation system, GPS	Navigation	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Laser and Satellite-based Navigation	TRAM Package(Communication and Navigation): undernose precision-stabilised turret, with a sensor package containing both infra-red and laser equipment	Communication System	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Laser and Satellite-based Navigation	INS updated with Litton AN/ASN-92 CAINS;	Communication System	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Laser and Satellite-based Navigation	new Communications-Navigation-Identification (CNI) equipment including AN/APX-72 IFF transponder;	Communication System	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Laser and Satellite-based Navigation	TAINS (Tercom-Aided Inertial Navigation System)/ Tercom (Terrain contour matching) and Inertial Navigation System (INS)	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068

		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Satellite-based navigation	GPS	Navigation	[illegible]	[illegible]	0.0110	0.5256	0.0058
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Satellite-based navigation	Inertial guidance system and GPS receiver for in-flight position updates to improve accuracy	Navigation	[illegible]	[illegible]	0.0118	0.2436	0.0029
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Satellite-based navigation	In shore-based silos or bases. Theater Mission Planning System (TMPS) - each having a theatre planning package and a rapid strike planning system. The theatre planning package plans various routes to prospective targets around the world using maps and da	Flight control and Management System	[illegible]	[illegible]	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Satellite-based navigation	TAINS (Tercom-Aided Inertial Navigation System) Tercom (Terrain contour matching) and Inertial Navigation System (INS)	Navigation	[illegible]	[illegible]	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Satellite-based navigation	GPS receiver with new five-element array antenna which, together with the DSMAC, is claimed to provide a 250 per cent improvement in CEP	Navigation	[illegible]	[illegible]	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Satellite-based navigation	Surface search: Norden/DRS SPS-67(V)3 [Ref 9]; G-band.	Sensor Systems			0.1528	0.8846	0.1352
		I		M	IT	Info management, IT in Communication, Modeling and Simulation	Satellite-based navigation	Raytheon SPS-64(V)9; I-band.	Navigation			0.1528	0.8846	0.1352

		I		M	IT	Info management IT in Communication Modeling and Simulation	Submarine Based Navigation	CCSM Command and Control System Medium include ESM, radar, defence and internal communications, submarine defensive warfare systems, navigation, fire control, periscope, imaging, navigation sensor system interface, Tactical data network, Tactical	Flight control and Management System			0.7104	0.7051	0.0778
		I		M	IT	Info management IT in Communication Modeling and Simulation	Laser and Submarine based Navigation	INS	Navigation	[illegible]	[illegible]	0.0429	0.2564	0.0109
		I		M	IT	Info management IT in Communication Modeling and Simulation	Laser and Submarine based Navigation	AN/ASN-92 CAINS carrier aircraft inertial navigation system, GPS	Navigation	[illegible]	[illegible]	0.0159	0.4231	0.0067
		I		M	IT	Info management IT in Communication Modeling and Simulation	Laser and Submarine based Navigation	HMMP Package/Communication and Navigation/ underwater platform stabilized turret, with a sensor package containing both infra red and laser equipment	Communication System	[illegible]	[illegible]	0.0128	0.2436	0.0031
		I		M	IT	Info management IT in Communication Modeling and Simulation	Laser and Submarine based Navigation	INS updated with Ultra AN/ASN-92 CAINS	Communication System	[illegible]	[illegible]	0.0128	0.2436	0.0031
		I		M	IT	Info management IT in Communication Modeling and Simulation	Laser and Submarine based Navigation	Link Communications, Navigation identification (CNI) equipment including AN/ARK-72 (V) 1 transmitter	Communication System	[illegible]	[illegible]	0.0128	0.2436	0.0031
		I		M	IT	Info management IT in Communication Modeling and Simulation	Laser and Submarine based Navigation	LN/N3 (Honeywell) Inertial Navigation System/ Tactical Display control/ Weapons and Inertial Navigation System (INS)	Navigation	[illegible]	[illegible]	0.0077	0.8846	0.0068

		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Radar Navigation	Doppler	Navigation	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Radar Navigation	BPS 16; I-band	Navigation	NSSN Virginia Class Submarine	8,899.0	0.1104	0.7051	0.0778
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Scene Matching Navigation	Digital Scene Matching Area Correlator (DSMAC)	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	inertial guidance system	inertial guidance system and GPS receiver for in-flight position updates to improve accuracy	Navigation	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	inertial guidance system	guidance inertial reference unit	Navigation	AMRAAM Advanced Medium Range Air-to-air Missile	589.1	0.0094	0.3974	0.0037
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	inertial guidance system	Tacan(Tactical air navigation): URN 25 [Ref 11]. IFF Mk XII AIMS UPX-29.	Navigation	DDG-51 AEGIS Destroyer	8,544.8	0.1528	0.8846	0.1352
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	inertial guidance system	Ground based Interceptor(GBIs): includes IR/Vis Seeker, IMU(inertial measurement unit), Integrated Communications, Antenna	Sensor Systems	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925

		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	Litton LR-80 (AN/ASN-143) strapdown AHRS	Navigation	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	AN/ASN-50 heading and attitude reference system	Navigation	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	three-axis attitude reference system	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	CCD Camera which uses an 18 mm second-generation image intensifier for night or bad weather operations	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	CCD Camera which uses an 18 mm second-generation image intensifier for night or bad weather operations	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	Surface search: Norden/DRS SPS-67(V)3 [Ref 9], G-band.	Sensor Systems	DDG-51 AEGIS Destroyer	8,544.8	0.1528	0.8846	0.1352
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	Position/Navigation System (POS/NAV)	Navigation	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042

		I		M	IT	Info management IT in Communication Modelling and Simulation	Radar Navigation	Doppler	Navigation	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
		I		M	IT	Info management IT in Communication Modelling and Simulation	Radar Navigation	BPS 16, I-band	Navigation			0.1104	0.7051	0.0778
		I		M	IT	Info management IT in Communication Modelling and Simulation	Scene Matching Navigation	Digital Scene Matching Area Correlator (DSMAC)	Navigation	[illegible]	[illegible]	0.0077	0.8846	0.0068
		I		M	IT	Info management IT in Communication Modelling and Simulation	Inertial guidance system	inertial guidance system and GPS receiver for in-flight position updates to improve accuracy	Navigation	[illegible]	[illegible]	0.0118	0.2436	0.0029
		I		M	IT	Info management IT in Communication Modelling and Simulation	Inertial guidance system	guidance inertial reference unit	Navigation	[illegible]	[illegible]	0.0094	0.3974	0.0037
		I		M	IT	Info management IT in Communication Modelling and Simulation	Inertial guidance system	Tacan(Tactical air navigation); URN 25 [Ref 11] IFF Mk XII AIMS UPX-29	Navigation			0.1528	0.8846	0.1352
		I		M	IT	Info management IT in Communication Modelling and Simulation	Inertial guidance system	Ground based interceptor(GBIs): includes IR/Vis Seeker, IMU(inertial measurement unit), Integrated Communications, Antenna	Sensor Systems	National Missile Defense (NMD)	29,551.4	0.3355	0.8718	0.2925

		I		M	IT	Info management IT in Communication, Modeling and Simulation	Navigation reference System	Litton LR-80 (AN/ASN-143) strapdown AHRS	Navigation	AH-64D Apache	2.666.5	0.0420	0.2564	0.0109
		I		M	IT	Info management IT in Communication, Modeling and Simulation	Navigation reference System	AN/ASN-90 heading and attitude reference system	Navigation	[illegible]	[illegible]	0.0159	0.4231	0.0067
		I		M	IT	Info management IT in Communication, Modeling and Simulation	Navigation reference System	three-axes attitude reference system	Navigation	[illegible]	[illegible]	0.0077	0.8846	0.0068
		I		M	IT	Info management IT in Communication, Modeling and Simulation	Navigation reference System	CCD Camera which uses an 18 mm second-generation image intensifier for night or bad weather operations	Navigation	[illegible]	[illegible]	0.0077	0.8846	0.0068
		I		M	IT	Info management IT in Communication, Modeling and Simulation	Navigation reference System	CCD Camera which uses an 18 mm second-generation image intensifier for night or bad weather operations	Navigation	[illegible]	[illegible]	0.0077	0.8846	0.0068
		I		M	IT	Info management IT in Communication, Modeling and Simulation	Navigation reference System	Surface search: Norden/DRS SPS-67(V)3 [Ref 9] G-band	Sensor Systems			0.1528	0.8846	0.1352
		I		M	IT	Info management IT in Communication, Modeling and Simulation	Navigation reference System	Position Navigation System (POSNAV)	Navigation	[illegible]	[illegible]	0.0220	0.1923	0.0042

		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	GPS receivers in multiple configurations: capable of processing signals from multiple satellites simultaneously, expediting initial acquisition times	Navigation	NAVSTAR Global Positioning System	1,461.4	0.0234	0.4359	0.0102
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	high-accuracy inertial reference units	Navigation	ABL Airborne Laser	1,459.9	0.0234	0.4231	0.0099
	S	I				Software and System Engineering, Info Management	Recording system(flight incident, cruise data)	DRS Technologies deployable flight incident recorder set (DFIRS)	Navigation	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
	S	I				Software and System Engineering, Info Management	Recording system(flight incident, cruise data)	The rapid strike planning system incorporates visual data from airborne, and possibly spaceborne, reconnaissance. Once the data has been processed in tape form it is transmitted through UHF satellite link to the ships where the data is stored, then upload	Flight control and Management System	TOMAHAWK	481.9	0.0077	0.8846	0.0068
					IT	IT in Communication	Encrypted wireless communication	SINCGARS secure radios	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
					IT	IT in Communication	Encrypted wireless communication	AN/ARC-164 StealthComm	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
					IT	IT in Communication	Encrypted wireless communication	AN/ARC-222 SINCGARS secure UHF/VHF;	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
					IT	IT in Communication	Encrypted wireless communication	AN/ARC-220 UHF to be retrofitted;	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
					IT	IT in Communication	Encrypted wireless communication	KY-28/58/TSEC crypto secure voice,	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
					IT	IT in Communication	Encrypted wireless communication	AN/APX-100 IFF unit with KIT-1A secure encoding;	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109

								on							
						IT	IT in Communication	Encrypted wireless communication	C-8157 secure voice control;	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
						IT	IT in Communication	Encrypted wireless communication	AN/ARC-210 secure UHF/VHF radio	Communication System	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
						IT	IT in Communication	Encrypted wireless communication	joint star platform also relays messages between GSMs over the same secure datalink	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communication	encrypted UHF radios which can be operated independently in either anti-jam or fixed-frequency modes	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communication	VHF radios, encrypted and with growth provisions for SINCGARS	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communication	encrypted HF radios	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communication	AN/UYQ-70 advanced display systems:include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System	DDG-51 AEGIS Destroyer	9,544.8	0.1528	0.8846	0.1352
						IT	IT in Communication	Encrypted wireless communication	CCSM(Command and Control System Module): include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, farbic optics network, tactic	Flight control and Management System	NSSN Virginia Class Submarine	7,369.6	0.1104	0.7051	0.0778
						IT	IT in Communication	Encrypted wireless communication	VLF, LF, MF, HF, VHF, UHF and D-band GPS reception (with simultaneous capability), and VHF/UHF line of sight transmission.	Navigation	NAVSTAR Global Positioning System	1,461.4	0.0234	0.4359	0.0102

		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	GPS receivers in multiple configurations: capable of processing signals from multiple satellites simultaneously, expediting initial acquisition times	Navigation	NAVSTAR Global Positioning System	1,461.4	0.0234	0.4359	0.0102
		I		M	IT	Info management, IT in Communication, Modelling and Simulation	Navigation reference System	high-accuracy inertial reference units	Navigation			0.0234	0.4231	0.0099
	S	I				Software and System Engineering, Info Management	Recording system(flight incident, cruise data)	DRS Technologies deployable flight incident recorder set (DFIRS)	Navigation	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
	S	I				Software and System Engineering, Info Management	Recording system(flight incident, cruise data)	The rapid strike planning system incorporates visual data from airborne, and possibly spaceborne, reconnaissance. Once the data has been processed in tape form it is transmitted through UHF satellite link to the ships where the data is stored, then upload	Flight control and Management System	TOMAHAWK	4,673	0.0077	0.8846	0.0068
					IT	IT in Communication	Encrypted wireless communication	SINCGARS secure radios	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
					IT	IT in Communication	Encrypted wireless communication	AN/ARC-164 StealthComm	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
					IT	IT in Communication	Encrypted wireless communication	AN/ARC-222 SINCGARS secure UHF/VHF	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
					IT	IT in Communication	Encrypted wireless communication	AN/ARC-220 UHF to be retrofitted.	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
					IT	IT in Communication	Encrypted wireless communication	KY-28/58/TSEC crypto secure voice.	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
					IT	IT in Communication	Encrypted wireless communication	AN/APX-100 IFF unit with KIT-1A secure encoding.	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109

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						IT	IT in Communication	Encrypted wireless communicati on	C-8157 secure voice control;	Communication System	AH-64D Apache	2.666 5	0.0426	0.2564	0.0109
						IT	IT in Communication	Encrypted wireless communicati on	AN ARC-210 secure UHF/VHF radio	Communication System	F/A-18E/F Super Hornet	1.44	0.1512	0.3590	0.0543
						IT	IT in Communication	Encrypted wireless communicati on	joint star platform also relays messages between GSMs over the same secure datalink	Communication System	Joint Stars (E-8C) designated AN/APY-3	1.237 6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communicati on	encrypted UHF radios which can be operated independently in either anti-jam or fixed-frequency modes	Communication System	Joint Stars (E-8C) designated AN/APY-3	1.237 6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communicati on	VHF radios, encrypted and with growth provisions for SINCGARS	Communication System	Joint Stars (E-8C) designated AN/APY-3	1.237 6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communicati on	encrypted HF radios	Communication System	Joint Stars (E-8C) designated AN/APY-3	1.237 6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communicati on	AN/UYQ-70 advanced display systems include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System			0.1528	0.8846	0.1352
						IT	IT in Communication	Encrypted wireless communicati on	CCSM(Command and Control System Module) include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, fartnc optics network, tactic	Flight control and Management System			0.1104	0.7051	0.0778
						IT	IT in Communication	Encrypted wireless communicati on	VLF, LF, MF, HF, VHF, UHF and D-band GPS reception (with simultaneous capability), and VHF/UHF line of sight transmission	Navigation	NAVSTAR Global Positioning System	1.461 4	0.0234	0.4359	0.0102

						IT	IT in Communication	Encrypted wireless communication	BMC4I segment provides surveillance, communication, planning, and the central command and control of the ABL weapon system	Flight control and Management System	ABL Airborne Laser	1,459.9	0.0234	0.4231	0.0099
						IT	IT in Communication	Encrypted wireless communication	TRAM Package(Communication and Navigation): undernose precision-stabilised turret, with a sensor package containing both infra-red and laser equipment	Communication System	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
						IT	IT in Communication	Encrypted wireless communication	new Communications-Navigation-Identification (CNI) equipment including AN/APX-72 IFF transponder;	Communication System	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
						IT	IT in Communication	Encrypted wireless communication	VLF/LF receiver	Communication System	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
						IT	IT in Communication	Encrypted wireless communication	within E-8C, radar data are distributed via a local network to an encrypted, highly jam-resistant Surveillance and Control DataLink (SCDL) for transmission to mobile army Ground Station Modules (GSMs) and other communications nodes such as national decisi	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communication	Radar service requests can be uplinked from the GSMs to the Joint STARS platform	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communication	AN/UYQ-70 advanced display systems:include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
						IT	IT in Communication	Encrypted wireless communication	Inter-Vehicular Information System (IVIS),	Communication System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
						IT	IT in Communication	Encrypted wireless communication	Radio Interface Unit (RIU)	Communication System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
						IT	IT in Communication	Encrypted wireless communication	HF, VHF, UHF and AFSATCOM connectivity for both voice and data (Link 16 and TIBS), fully supporting the TMD FOS.	Communication System	ABL Airborne Laser	1,459.9	0.0234	0.4231	0.0099

						IT	IT in Communication	Encrypted Wireless datalink communication	data modem (Symetrics Industries): digital air-to-ground data communications	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
						IT	IT in Communication	Encrypted Wireless datalink communication	Hawkeye 2000. Lockheed Martin AN/ALQ-217 ESM and Multi-Mission Advanced Tactical Terminal (MATT) for data communications	Communication System	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
						IT	IT in Communication	Encrypted Wireless datalink communication	secure datalinks	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted Wireless datalink communication	within E-8C, radar data are distributed via a local network to an encrypted, highly jam-resistant Surveillance and Control DataLink (SCDL) for transmission to mobile army Ground Station Modules (GSMs) and other communications nodes such as national decisi	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted Wireless datalink communication	The rapid strike planning system incorporates visual data from airborne, and possibly spaceborne, reconnaissance. Once the data has been processed in tape form it is transmitted through UHF satellite link to the ships where the data is stored, then upload	Flight control and Management System	TOMAHAWK	481.9	0.0077	0.8846	0.0068
						IT	IT in Communication	Encrypted Wireless datalink communication	receive commands from, and be monitored by, the launch platform through a UHF satellite communications system and a video datalink system, compatible with the airborne AN/AAW-13, to alter target assignments and to conduct damage assessment	Communication System	TOMAHAWK	481.9	0.0077	0.8846	0.0068
						IT	IT in Communication	Encrypted Wireless datalink communication	command link receiver antennas, which receive guidance updates on target position and manoeuvre from the launch aircraft	Communication System	AMRAAM Advanced Medium Range Air-to-air Missile	589.1	0.0094	0.3974	0.0037
						IT	IT in Communication	Encrypted Wireless datalink communication	Mk 116 ASWCS directly interfaces with shipboard acoustic sensors (typically AN/SQS-53, AN/SQR-19 and AN/SQQ-28), radar, ESM(entry monitor system), and receives offboard sensor data via datalink.	Sensor Systems	[illegible]	[illegible]	0.1528	0.8846	0.1352

						IT	IT in Communication	Encrypted wireless communication	BMC4I segment provides surveillance, communication, planning, and the central command and control of the ABL weapon system	Flight control and Management System			0.0234	0.4231	0.0099
						IT	IT in Communication	Encrypted wireless communication	TRAM Package(Communication and Navigation) undernose precision-stabilised turret, with a sensor package containing both infra-red and laser equipment	Communication System	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
						IT	IT in Communication	Encrypted wireless communication	new Communications-Navigation-Identification (CNI) equipment including AN/APX-72 IFF transponder.	Communication System	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
						IT	IT in Communication	Encrypted wireless communication	VLF/LF receiver	Communication System	B-2A Spirit (Stealth Bomber)	567.6	0.0110	0.5256	0.0058
						IT	IT in Communication	Encrypted wireless communication	within E-8C, radar data are distributed via a local network to an encrypted, highly jam-resistant Surveillance and Control DataLink (SCDL) for transmission to mobile army Ground Station Modules (GSMs) and other communications nodes such as national decisi	Communication System	Joint Stars (E-8C) designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communication	Radar service requests can be uplinked from the GSMs to the Joint STARS platform	Communication System	Joint Stars (E-8C) designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted wireless communication	AN/UYQ-70 advanced display systems include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System			0.1528	0.8846	0.1352
						IT	IT in Communication	Encrypted wireless communication	Inter-Vehicular Information System (IVIS)	Communication System	[illegible]	[illegible]	0.0220	0.1923	0.0042
						IT	IT in Communication	Encrypted wireless communication	Radio Interface Unit (RIU)	Communication System	[illegible]	[illegible]	0.0220	0.1923	0.0042
						IT	IT in Communication	Encrypted wireless communication	HF, VHF, UHF and AFSATCOM connectivity for both voice and data (Link 16 and TIBS), fully supporting the TMD FOS	Communication System			0.0234	0.4231	0.0099

							IT in Communication	Encrypted Wireless data link communication	data modem (Symetrics Industries) digital air-to-ground data communications	Communication System	AH-64D Apache	2 666.5	0.0426	0.2564	0.0109
							IT in Communication	Encrypted Wireless data link communication	Hawkeye 2000 - Lockheed Martin AN/ALQ-217 ESM and Multi-Mission Advanced Tactical Terminal (MATT) for data communications	Communication System			0.0159	0.4231	0.0067
							IT in Communication	Encrypted Wireless data link communication	secure datalinks	Communication System	Joint Stars (E-8C) designated AN/APY-3	1 237.1	0.0198	0.6923	0.0137
							IT in Communication	Encrypted Wireless data link communication	within E-8C, radar data are distributed via a local network to an encrypted, highly jam-resistant Surveillance and Control DataLink (SCDL) for transmission to mobile army Ground Station Modules (GSMs) and other communications nodes such as national decisi	Communication System	Joint Stars (E-8C) designated AN/APY-3	1 237.1	0.0198	0.6923	0.0137
							IT in Communication	Encrypted Wireless data link communication	The rapid strike planning system incorporates visual data from airborne, and possibly spaceborne, reconnaissance. Once the data has been processed in tape form it is transmitted through UHF satellite link to the ships where the data is stored, then upload	Flight control and Management System	TOMAHAWK	997.9	0.0077	0.8846	0.0068
							IT in Communication	Encrypted Wireless data link communication	receive commands from, and be monitored by, the launch platform through a UHF satellite communications system and a video datalink system, compatible with the airborne AN/AAW-13, to alter target assignments and to conduct damage assessment	Communication System	TOMAHAWK	997.9	0.0077	0.8846	0.0068
							IT in Communication	Encrypted Wireless data link communication	command link receiver antennas, which receive guidance updates on target position and manoeuvre from the launch aircraft	Communication System	TOMAHAWK	997.9	0.0194	0.3974	0.0077
							IT in Communication	Encrypted Wireless data link communication	Mk 116 ASWCS directly interfaces with shipboard acoustic sensors (typically AN/SQS-53, AN/SQR-19 and AN/SQQ-28) radar, ESM/early warning system, and receives offboard sensor data via datalink.	Sensor Systems			0.1528	0.5641	0.1952

							IT	IT in Communication	Encrypted Wireless datalink communication	TADIX B Tactical Information Exchange System (from DDG 72	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
							IT	IT in Communication	Encrypted Wireless datalink communication	AN/UYQ-70 advanced display systems:include new internal secure and non-secure communication solutions, thin client-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System	[illegible]	[illegible]	0.1528	0.8846	0.1352
							IT	IT in Communication	Encrypted Wireless datalink communication	LAMPS MK III datalink system provides full duplex, secure and highly reliable communications between airborne and shipboard platforms	Communication system	[illegible]	[illegible]	0.1528	0.8846	0.1352
							IT	IT in Communication	Encrypted Wireless datalink communication	TAC-X computer technology and asynchronous transfer mode networking technology.	communication system	[illegible]	[illegible]	0.1104	0.7051	0.0778
							IT	IT in Communication	Encrypted Wireless datalink communication	FOS; a mission data processing subsystem, utilising ruggedised commercial hardware, hosts the BMC4I software and supports the distribution of information between the weapon system segments over the Local Area Network (LAN).	Flight control and Management System	[illegible]	[illegible]	0.0234	0.4231	0.0099
							IT	IT in Communication	Encrypted Wireless datalink communication	HF, VHF, UHF and AFSATCOM connectivity for both voice and data (Link 16 and TIBS), fully supporting the TMD FOS.	Communication System	[illegible]	[illegible]	0.0234	0.4231	0.0099
							IT	IT in Communication	Encrypted Wireless datalink communication	Ground based Interceptor(GBIs): includes IR/Vis Seeker, IMU(inertial measurement unit), Integrated Communications, Antenna	Sensor Systems	National Missile Defense (NMD)	20.959 4	0.3355	0.8718	0.2925
							IT	IT in Communication	Encrypted Wireless datalink communication	X-band/ Ground based radar (XBR): high frequency and advanced radar signal processing technology to improve target resolution, which permits the radar to more accurately discriminate between closely-spaced objects, perform tracking, discrimination, and ki	Sensor Systems	National Missile Defense (NMD)	20.959 4	0.3355	0.8718	0.2925

						IT	IT in Communication	Encrypted Wireless datalink communicati on	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
						IT	IT in Communication	Encrypted Wireless datalink communicati on	In-flight Interceptor Communication System (IFICS): geographically distributed ground stations that provide communications links to the GBI for in-flight target and status information between the GBI and BMC2, consist of a radio transmitter/receiver	Communication System	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
						IT	IT in Communication	Encrypted satellite-based communicati on	satellite-based voice and data communications capability	Communication System	E-2C Hawkeye	395.2	0.0159	0.4231	0.0067
						IT	IT in Communication	Encrypted satellite-based communicati on	Milstar satcom in Block 30 Milstar satellite communications terminal	Communication System	B-2A Spirit (Stealth bomber)	687.6	0.0110	0.5256	0.0058
						IT	IT in Communication	Encrypted satellite-based communicati on	Beyond Line Of Sight transmission can be made by SATCOM links.	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	Encrypted satellite-based communicati on	receive commands from, and be monitored by, the launch platform through a UHF satellite communications system and a video datalink system, compatible with the airborne AN/AAW-13, to alter target assignments and to conduct damage assessment	Communication System	TOMAHAWK	481.9	0.0077	0.8846	0.0068
						IT	IT in Communication	Encrypted satellite-based communicati on	SATCOM SRR-1, WSC-3 (UHF), USC-38 (EHF)	communication system	[illegible]	[illegible]	0.1528	0.8846	0.1352
						IT	IT in Communication	Encrypted satellite-based communicati on	SHF frequency antenna for satellite links for secure, high volume, high data rate with instantaneous transmission of images to other ships and submarines. The communications suite will also enable the boat to communicate with offboard underwater, surface.	communication system	[illegible]	[illegible]	0.1104	0.7051	0.0778

						IT	IT in Communication	Encrypted Wireless datalink communication	TADIX B Tactical Information Exchange System (from DDG 72	Flight control and Management System			0.1528	0.8846	0.7352
						IT	IT in Communication	Encrypted Wireless datalink communication	AN/UYQ-70 advanced display systems, include new internal secure and non-secure communication modules, Pcn (Hard-based Low Mass workstations, and the Computer-Aided Dead Reckoning Tracer (CADRT), which will replace old electro-mechanical Dead Reckoning	Flight control and Management System			0.1528	0.8846	0.7352
						IT	IT in Communication	Encrypted Wireless datalink communication	LAMPS MK III datalink system provides full duplex secure and highly reliable communications between airborne and shipboard platforms	Communication system			0.1528	0.8846	0.7352
						IT	IT in Communication	Encrypted Wireless datalink communication	TACAN computer technology and asynchronous transfer mode networking technology	communication system			0.1104	0.7051	0.0778
						IT	IT in Communication	Encrypted Wireless datalink communication	FOS: a mission data processing subsystem, utilising ruggedized commercial hardware, hosts the BMC4I software and supports the distribution of information between the weapon system segments over the Local Area Network (LAN)	Flight control and Management System			0.0234	0.4241	0.0099
						IT	IT in Communication	Encrypted Wireless datalink communication	HF, VHF, UHF and AFSATCOM connectivity for both voice and data (Link 16 and TBSS) fully supporting the TMD FOS.	Communication System			0.0234	0.4241	0.0099
						IT	IT in Communication	Encrypted Wireless datalink communication	Ground-based Electro-Optical (GEO) Deep Space Surveillance (ARGOS) system (operational) and Integrated Communications Wedge	Sensor Systems			0.0355	0.8718	0.2929
						IT	IT in Communication	Encrypted Wireless datalink communication	X-band Ground-based radar (XBR) high Frequency and advanced radar signal processing technology to improve target resolution, which permits the radar to more accurately discriminate between closely-spaced objects, perform tracking discrimination, and ki	Sensor Systems			0.0355	0.8718	0.2929

						IT	IT or Communication	Encrypted Wireless datalink communication	BMC2 (Battle Management, Command and Control) unit, provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to [illegible]	Flight control and Management System	[illegible]	[illegible]	0.3355	0.8718	0.2925
						IT	IT or Communication	Encrypted Wireless datalink communication	In-flight Intercepter Communication System (IFICS): geographically distributed ground stations that provide communications links to the GBI for in-flight target and status information between the GBI and BMC2. Consist of a radio transmitter/receiver	Communication System	[illegible]	[illegible]	0.3355	0.8718	0.2925
						IT	IT or Communication	Encrypted satellite based communication	Satellite based command and data communication capability	Communication System	[illegible]	[illegible]	[illegible]	0.4231	0.0967
						IT	IT or Communication	Encrypted satellite based communication	Mobile satcom is Ku-band for Mobile satellite communications terminal	Communication System	[illegible]	[illegible]	0.0330	0.5256	0.0656
						IT	IT or Communication	Encrypted satellite based communication	Beyond Line Of Sight transmission can be made by SATCOM links	Communication System	Anti-SAM E/E, IRC designated AN/ARC-[illegible]	1.2173	0.0198	0.6923	0.0137
						IT	IT or Communication	Encrypted satellite based communication	receive commands from, and be monitored by, the launch platform through a UHF satellite communications system and a video datalink system, compatible with the airborne AN/AAW-13, to alter target assignments and to conduct damage assessment	Communication System	[illegible]	[illegible]	0.8877	0.8846	0.0908
						IT	IT or Communication	Encrypted satellite based communication	SATCOM SHF-1, WSC-3 (UHF), USC-38 (EHF)	communication system			0.1928	0.6846	0.1352
						IT	IT or Communication	Encrypted satellite based communication	SHF Frequency antenna for satellite links for secure, high volume, high data rate with instantaneous transmission of images to other ships and submarines. The communications suite will allow weapons the load to communicate with different [illegible]	communication system			0.1594	0.7051	0.0729

						IT	IT in Communication	Encrypted satellite-based communication	Joint Maritime Command Information System (to allow the 'Virginia' class to interoperate with other ships, submarines, aircraft, ground units and command activities	communication system	[illegible]	[illegible]	0.1104	0.7051	0.0778
						IT	IT in Communication	Encrypted satellite-based communication	DoD military satellite communications (MILSATCOM) systems support three user communities: the wideband, high data rate users, the mobile users and the nuclear capable forces	communication system	DSCS (Defense Satellite Communications System)	298.4	0.0048	0.6410	0.0031
						IT	IT in Communication	Encrypted satellite-based communication	digital communications subsystems	communication system	DSCS (Defense Satellite Communications System)	298.4	0.0048	0.6410	0.0031
						IT	IT in Communication	Encrypted satellite-based communication	VLF, LF, MF, HF, VHF, UHF and D-band GPS reception (with simultaneous capability), and VHF/UHF line of sight transmission.	Navigation	NAVSTAR Global Positioning System	1,461.4	0.0234	0.4359	0.0102
						IT	IT in Communication	Encrypted satellite-based communication	GPS receivers in multiple configurations: capable of processing signals from multiple satellites simultaneously, expediting initial acquisition times	Navigation	NAVSTAR Global Positioning System	1,461.4	0.0234	0.4359	0.0102
						IT	IT in Communication	Encrypted satellite-based communication	BMC4I segment provides surveillance, communication, planning, and the central command and control of the ABL weapon system	Flight control and Management System	ABL [illegible]	[illegible]	0.0234	0.4231	0.0099
						IT	IT in Communication	Encrypted satellite-based communication	HF, VHF, UHF and AFSATCOM connectivity for both voice and data (Link 16 and TIBS), fully supporting the TMD FOS.	Communication System	ABL [illegible]	[illegible]	0.0234	0.4231	0.0099
						IT	IT in Communication	Encrypted satellite-based communication	Ground based Interceptor(GBIs): includes IR/Vis Seeker, IMU(inertial measurement unit), Integrated Communications, Antenna	Sensor Systems	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
						IT	IT in Communication	Encrypted satellite-based communication	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925

						IT	IT in Communication	Encrypted satellite-based communication	In-flight Interceptor Communication System (IFICS): geographically distributed ground stations that provide communications links to the GBI for in-flight target and status information between the GBI and BMC2, consist of a radio transmitter/receiver	Communication System	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
						IT	IT in Communication	In-flight or in-vessel communication	C-8157 secure voice control;	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
						IT	IT in Communication	In-flight or in-vessel communication	C-10414 Tempest intercom.	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
						IT	IT in Communication	In-flight or in-vessel communication	AN/AIC-14A intercom, AN/ARC-210 wideband/narrowband radio to be installed on Hawkeye 2000	Communication System	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
						IT	IT in Communication	In-flight or in-vessel communication	ICS-150X intercom	Communication System	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
						IT	IT in Communication	In-flight or in-vessel communication	Multiple intercom nets, fixed and assignable	Communication System	Joint Stars (E-8C) designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
						IT	IT in Communication	In-flight or in-vessel communication	AN/STC-1 and AN/STC-2 Integrated Voice Communication System (IVCS)	Communication system	[illegible]	[illegible]	0.1528	0.8846	0.1352
						IT	IT in Communication	In-flight or in-vessel communication	CCSM(Command and Control System Module): include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, farbic optics network, tactic	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S			M			Software and System Engineering, Modelling and Simulation	RF Seeker	Longbow radars	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109

						IT	IT in Communication	Encrypted satellite-based communication	Joint Maritime Command Information System (to allow the 'Virginia' class to interoperate with other ships, submarines, aircraft, ground units and command activities	communication system			0.1104	0.7051	0.0778
						IT	IT in Communication	Encrypted satellite-based communication	DoD military satellite communications (MILSATCOM) systems support three user communities: the wideband, high data rate users, the mobile users and the nuclear capable forces	communication system	[illegible]	[illegible]	0.0048	0.6410	0.0031
						IT	IT in Communication	Encrypted satellite-based communication	digital communications subsystems	communication system	[illegible]	[illegible]	0.0048	0.6410	0.0031
						IT	IT in Communication	Encrypted satellite-based communication	VLF, LF, MF, HF, VHF, UHF and D-band GPS reception (with simultaneous capability), and VHF/UHF line of sight transmission	Navigation	NAVSTAR Global Positioning System	1.4to1.4	0.0234	0.4359	0.0102
						IT	IT in Communication	Encrypted satellite-based communication	GPS receivers in multiple configurations: capable of processing signals from multiple satellites simultaneously, expediting initial acquisition times	Navigation	NAVSTAR Global Positioning System	1.4to1.4	0.0234	0.4359	0.0102
						IT	IT in Communication	Encrypted satellite-based communication	BMC4I segment provides surveillance, communication, planning, and the central command and control of the ABL weapon system	Flight control and Management System			0.0234	0.4231	0.0099
						IT	IT in Communication	Encrypted satellite-based communication	HF, VHF, UHF and AFSATCOM connectivity for both voice and data (Link 16 and TIBS), fully supporting the TMD FOS	Communication System			0.0234	0.4231	0.0099
						IT	IT in Communication	Encrypted satellite-based communication	Ground based Interceptor(GBIs): includes IR/Vis Seeker, IMU(inertial measurement unit), Integrated Communications, Antenna	Sensor Systems	National Missile Defense (NMD)	20.99to4	0.3355	0.8718	0.2925
						IT	IT in Communication	Encrypted satellite-based communication	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20.99to4	0.3355	0.8718	0.2925

						IT	IT in Communication	Encrypted satellite-based communication	In-flight Interceptor Communication System (IFICS): geographically distributed ground stations that provide communications links to the GBI for in-flight target and status information between the GBI and BMC2; consist of a radio transmitter/receiver.	Communication System	National Missile Defence (NMD)	2.0109E-4	0.3355	0.8718	0.2925
						IT	IT in Communication	In-flight or in-vessel communication	C-8157 secure voice control;	Communication System	AH-64D Apache	2.666E-5	0.0426	0.2564	0.0109
						IT	IT in Communication	In-flight or in-vessel communication	C-10414 Tempest intercom;	Communication System	AH-64D Apache	2.666E-5	0.0426	0.2564	0.0109
						IT	IT in Communication	In-flight or in-vessel communications	AN/AIC-14A intercom; AN/ARC-210 wideband/narrowband radio to be installed on Hawkeye 2000	Communication System	E-2C Hawkeye	1.88E-4	0.0159	0.4231	0.0067
						IT	IT in Communication	In-flight or in-vessel communications	ICS-150X intercom	Communication System	C-130 Hercules (C-130J-30)	1.88E-4	0.0110	0.5256	0.0058
						IT	IT in Communication	In-flight or in-vessel communications	Multiple intercom nets, fixed and assignable	Communication System	Joint Strike Fighter (JSF) designated AN/APY-8	1.247E-4	0.0198	0.6923	0.0137
						IT	IT in Communication	In-flight or in-vessel communication	AN/STC-1 and AN/STC-2 Integrated Voice Communication System (IVCS).	Communication system			0.1528	0.8846	0.1352
						IT	IT in Communication	In-flight or in-vessel communication	CCSM(Command and Control System Module) include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, fabric optics network, tactic	Flight control and Management System			0.1104	0.7051	0.0778
	S			M			Software and System Engineering, Modelling and Simulation	RF Sensor	Longbow radars	Sensor Systems	AH-64D Apache	2.666E-5	0.0426	0.2564	0.0109

	S			M		Software and System Engineering, Modelling and Simulation	RF Seeker	an imaging dual-colour infra-red and millimetric wave radar seeker head	Sensor Systems	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029
	S			M		Software and System Engineering, Modelling and Simulation	RF Seeker	DSQ-28 frequency-agile, active radar seeker	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
	S			M		Software and System Engineering, Modelling and Simulation	RF Seeker	Ground based Interceptor(GBIs): includes IR/Vis Seeker, IMU(inertial measurement unit), Integrated Communications, Antenna	Sensor Systems	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
	S			M		Software and System Engineering, Modelling and Simulation	Transponder	AN/APX-100 IFF unit with KIT-1A secure encoding;	Communication System	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S			M		Software and System Engineering, Modelling and Simulation	Transponder	new Communications-Navigation-Identification (CNI) equipment including AN/APX-72 IFF transponder;	Communication System	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
	S			M		Software and System Engineering, Modelling and Simulation	Transponder	Hazeltine combined interrogator transponder	Communication System	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
	S			M		Software and System Engineering, Modelling and Simulation	Transponder	satellite transponder(TRW systems) consisted of a multichannel repeater with cross-linked channels, a receive and transmit Earth Coverage (EC) antenna, a steerable Narrow Coverage (NC) antenna and a steerable Area Coverage (AC) antenna	Sensor Systems	DSCS (Defense Satellite Communications System)	298.4	0.0048	0.6410	0.0031
	S			M		Software and System Engineering, Modelling and Simulation	Transponder	six-channel communications transponder with each channel operating through its RF amplifier serves the users. This allows compatible grouping of users for efficient use of the frequency spectrum and transponder power	communication system	DSCS (Defense Satellite Communications System)	298.4	0.0048	0.6410	0.0031

	S			M		Software and System Engineering, Modelling and Simulation	Radar Beamformer	within E-8C, radar data are distributed via a local network to an encrypted, highly jam-resistant Surveillance and Control DataLink (SCDL) for transmission to mobile army Ground Station Modules (GSMs) and other communications nodes such as national decisi	Communication System	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
	S			M		Software and System Engineering, Modelling and Simulation	Radar Beamformer	Raytheon AN/APG-73 multimode	Sensor Systems	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
	S			M		Software and System Engineering, Modelling and Simulation	Radar Beamformer	AN/APQ-181 low-probability-of-intercept (LPI) J-band covert strike radar	Sensor Systems	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
	S			M		Software and System Engineering, Modelling and Simulation	Radar Beamformer	advanced mulitmode radar system	Sensor Systems	Joint Stars (E-8C), designated AN/APY-3	1,237.6	0.0198	0.6923	0.0137
	S			M		Software and System Engineering, Modelling and Simulation	Radar Beamformer	Tacan(Tactical air navigation): URN 25 [Ref 11]. IFF Mk XII AIMS UPX-29.	Navigation	DDG-51 AEGIS Destroyer	9,544.9	0.1528	0.8846	0.1352
	S			M		Software and System Engineering, Modelling and Simulation	Radar Beamformer	CCSM(Command and Control System Module): include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, farbic optics network, tactic	Flight control and Management System	NSSN Virginia Class Submarine	6,897.6	0.1104	0.7051	0.0778
	S			M		Software and System Engineering, Modelling and Simulation	Radar Sensor	radar altimeter	Navigation	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S			M		Software and System Engineering, Modelling and Simulation	Radar Sensor	APN-194 radar altimeter	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068

	S			M	Software and System Engineering, Modeling and Simulation	RF Seeker	an imaging dual-colour infra-red and millimetre wave radar seeker head	Sensor Systems	[illegible]	[illegible]	0.0118	0.2436	0.0029
	S			M	Software and System Engineering, Modeling and Simulation	RF Seeker	DSQ-28 frequency-agile, active radar seeker	Navigation	TOMAHAWK	[illegible]	0.0077	0.8846	0.0068
	S			M	Software and System Engineering, Modeling and Simulation	RF Seeker	Ground based Interceptor(GBIs), includes IR/Vis Seeker, IMU(inertial measurement unit), Integrated Communications, Antenna	Sensor Systems	National Missile Defense (NMD)	20.0694	0.3355	0.8718	0.2925
	S			M	Software and System Engineering, Modeling and Simulation	Transponder	AN/APX-100 IFF unit with KIT-1A secure encoding	Communication System	AH-64D Apache	2.6865	0.0426	0.2564	0.0109
	S			M	Software and System Engineering, Modeling and Simulation	Transponder	new Communications-Navigation-Identification (CNI) equipment including AN/APX-72 IFF transponder	Communication System	[illegible]	[illegible]	0.0128	0.2436	0.0031
	S			M	Software and System Engineering, Modeling and Simulation	Transponder	Hazeltine combined interrogator transponder	Communication System	[illegible]	[illegible]	0.1512	0.3550	0.0543
	S			M	Software and System Engineering, Modeling and Simulation	Transponder	Satellite transponder(TRW systems) consisted of a multichannel repeater with cross-linked channels, a receive and transmit Earth Coverage (EC) antenna, a steerable Narrow Coverage (NC) antenna and a steerable Area Coverage (AC) antenna	Sensor Systems	[illegible]	[illegible]	0.0048	0.6410	0.0031
	S			M	Software and System Engineering, Modeling and Simulation	Transponder	six-channel communications transponder with each channel operating through its RF amplifier serves the users. This allows compatible grouping of users for efficient use of the frequency spectrum and transponder power	communication system	[illegible]	[illegible]	0.0048	0.6410	0.0031

	S			M	Software and System Engineering, Modeling and Simulation	Radar Beamformer	within E-8C, radar data are distributed via a local network to an encrypted, highly jam-resistant Surveillance and Control DataLink (SCDL) for transmission to mobile army Ground Station Modules (GSMs) and other communications nodes such as national decisi	Communication System	Joint Stars (E-8C) deployed AN/APY-3	1.237 E	0.0198	0.6923	0.0137
	S			M	Software and System Engineering, Modeling and Simulation	Radar Beamformer	Raytheon AN/APG-73 multimode	Sensor Systems	F-18 C/D F Hornet Hornet	0.440	0.1512	0.3590	0.0543
	S			M	Software and System Engineering, Modeling and Simulation	Radar Beamformer	AN/APQ-181 low probability of intercept (LPI) J-band covert strike radar	Sensor Systems			0.0170	0.6250	0.0058
	S			M	Software and System Engineering, Modeling and Simulation	Radar Beamformer	advanced multimode radar system	Sensor Systems	Joint Stars (E-8C) deployed AN/APY-3	1.237 E	0.0198	0.6923	0.0137
	S			M	Software and System Engineering, Modeling and Simulation	Radar Beamformer	Tacan(Tactical air navigation) URN 25 [Ref 11] FT- Mk XII AIMS UPX-29	Navigation			0.1528	0.8846	0.1352
	S			M	Software and System Engineering, Modeling and Simulation	Radar Beamformer	CCSM(Command and Contrlo System Module) include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, fanbr, optics network, tacts	Flight control and Management System			0.1104	0.7051	0.0778
	S			M	Software and System Engineering, Modeling and Simulation	Radar Sensor	radar altimeter	Navigation	AH-64D Apache	2.666 E	0.0426	0.2564	0.0109
	S			M	Software and System Engineering, Modeling and Simulation	Radar Sensor	APN-194 radar altimeter	Navigation	[illegible]	[illegible]	0.0077	0.8846	0.0068

	S			M	Software and System Engineering, Modeling and Simulation	Radar Sensor	guidance unit; contains the active radar terminal seeker, with a flat plate antenna and TWT amplified transmitter	Sensor Systems	AMRAAM			0.0094	0.3974	0.0037
	S			M	Software and System Engineering, Modeling and Simulation	Radar Sensor	Raytheon digital 3-D AN/MPQ-64 Ground Based Sensor (Sentinel) search and track radar with built-in IFF system	Sensor Systems	AGBS(GBS)			0.0094	0.3974	0.0037
	S			M	Software and System Engineering, Modeling and Simulation	Radar Sensor	Surface search: Norden/DRS SPS-67(V)3 [Ref 9] G-band	Sensor Systems				0.1528	0.8846	0.1352
	S			M	Software and System Engineering, Modeling and Simulation	Radar Sensor	Mk 116 ASWCS directly interfaces with shipboard acoustic sensors (typically AN/SQS-53, AN/SQR-19 and AN/SQQ-28), radar, ESM(entry monitor system), and receives offboard sensor data via datalink.	Sensor Systems				0.1528	0.8846	0.1352
	S			M	Software and System Engineering, Modeling and Simulation	Radar Sensor	Tacan(Tactical air navigation); URN 25 [Ref 11] IFF Mk XII AIMS UPX-29	Navigation				0.1528	0.8846	0.1352
	S			M	Software and System Engineering, Modeling and Simulation	Radar Sensor	X-band' Ground based radar (XBR); high frequency and advanced radar signal processing technology to improve target resolution, which permits the radar to more accurately discriminate between closely-spaced objects, perform tracking, discrimination, and ki	Sensor Systems	National Missile Defense (NMD)			0.3355	0.8718	0.2925
	S			M	Software and System Engineering, Modeling and Simulation	Radar Sensor	radar altimeter	Sensor Systems				0.0077	0.8846	0.0068
	S			M	Software and System Engineering, Modeling and Simulation	Radar Sensor	Raytheon Systems AN/APY-1/2 antenna: antenna array is subsystems provide radar sum and difference signals and IFF	Sensor Systems				0.0159	0.4231	0.0067

	S			M		Software and System Engineering, Modeling and Simulation	Radar Sensor	guidance unit: contains the active radar terminal seeker, with a flat plate antenna and TWT amplified transmitter	Sensor Systems	AMRAAM Advanced Medium Range Air-to-air Missile	589.1	0.0094	0.3974	0.0037
	S			M		Software and System Engineering, Modeling and Simulation	Radar Sensor	Raytheon digital 3-D AN/MPQ-64 Ground-Based Sensor (Sentinel) search and track radar with built-in IFF system	Sensor Systems	AMRAAM Advanced Medium Range Air-to-air Missile	589	0.0094	0.3974	0.0037
	S			M		Software and System Engineering, Modeling and Simulation	Radar Sensor	Surface search: Norden/DRS SPS-67(V)3 [Ref 9], G-band.	Sensor Systems	[illegible]	[illegible]	0.1528	0.8846	0.1352
	S			M		Software and System Engineering, Modeling and Simulation	Radar Sensor	Mk 116 ASWCS directly interfaces with shipboard acoustic sensors (typically AN/SQS-53, AN/SQR-19 and AN/SQQ-28), radar, ESM(entry monitor system), and receives offboard sensor data via datalink.	Sensor Systems	[illegible]	[illegible]	0.1528	0.8846	0.1352
	S			M		Software and System Engineering, Modeling and Simulation	Radar Sensor	Tacan(Tactical air navigation): URN 25 [Ref 11]. IFF: Mk XII AIMS UPX-29.	Navigation	[illegible]	[illegible]	0.1528	0.8846	0.1352
	S			M		Software and System Engineering, Modeling and Simulation	Radar Sensor	X-band/ Ground based radar (XBR): high frequency and advanced radar signal processing technology to improve target resolution, which permits the radar to more accurately discriminate between closely-spaced objects, perform tracking, discrimination, and ki	Sensor Systems	National Missile Defense (NMD)	20.959.4	0.3355	0.8718	0.2925
	S			M		Software and System Engineering, Modeling and Simulation	Radar Sensor	radar altimeter	Sensor Systems	TOMAHAWK	481.9	0.0077	0.8846	0.0068
	S			M		Software and System Engineering, Modeling and Simulation	Radar Sensor	Randtron Systems AN/AP-171 antenna: antenna arrays in rotodome provide radar sum and difference signals and IFF	Sensor Systems	E-2C Hawkeye	265.2	0.0159	0.4231	0.0067

	S			M	Software and System Engineering, Modelling and Simulation	Photonic sensor	TADS (target acquisition and designation sight) daylight sensor consists of TV camera with narrow (0° 50') and wide angle (4° 0') fields of view	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S			M	Software and System Engineering, Modelling and Simulation	Photonic sensor	Signals from the photonic and advanced ASTECS ESM (the AN/BLQ-10) sensors will be relayed to the Combat Control System Mk 2 and AN/BSY-2 command system via a fibre optic link and presented on flat panel displays	Sensor Systems	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S			M	Software and System Engineering, Modelling and Simulation	Laser range-finder/designator	TADS (target acquisition and designation sight) direct view optics (4° narrow and 18° wide angle); laser spot tracker; and International Laser Systems laser range-finder/designator	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S			M	Software and System Engineering, Modelling and Simulation	Laser range-finder/designator	TADS (target acquisition and designation sight) switchable eyesafe laser range-finder designator (SELRD)	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S			M	Software and System Engineering, Modelling and Simulation	Laser range-finder/designator	Laser Spot Detector (laser designator to mark target with a laser spot, on which the laser-guided weapons, or those from another aircraft, will home)	Sensor Systems	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
	S			M	Software and System Engineering, Modelling and Simulation	Laser range-finder/designator	Low Cost Autonomous Attack System (LOCAAS) guided by a laser radar (LADAR) and intended for defeating critical ground targets. The LADAR seeker acts as a high-resolution range measurement device determining absolute range to each pixel in the image and ge	Sensor Systems	ATACMS Army Tactical Missile System	736.9	0.0118	0.2436	0.0029
	S			M	Software and System Engineering, Modelling and Simulation	Laser range-finder/designator	advanced photonics masts (AN/BVS-1) fitted with LLTV, IR and a laser range-finder	Sensor Systems	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S			M	Software and System Engineering, Modelling and Simulation	Laser range-finder/designator	GPS-LOS Gunner's Primary Sight Lone of Sight System with Laser range-finder	Sensor Systems	M1A2 Abrams Tank Upgrade	1,372.7	0.0229	0.1923	0.0042

	S			M		Software and System Engineering, Modelling and Simulation	Laser range-finder/designator	fire-control system includes the laser range-finder, full-solution solid-state digital computer and stabilised day/thermal night sight.	Flight control and Management System	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
	S			M		Software and System Engineering, Modelling and Simulation	Laser range-finder/designator	low-power carbon dioxide laser range-finder	Sensor Systems	ABL Airborne Laser	1,419.9	0.0234	0.4231	0.0099
	S			M		Software and System Engineering, Modelling and Simulation	Laser range-finder/designator	Active Ranger System (ARS) house the Active Laser Ranger (ALR). The ALR consists of a modified LANTIRN 2000 system (see separate entry), with a high-power CO2 laser. The ALR will receive vector information from the Infra-Red Search and Track (IRST) system	Sensor Systems	ABL Airborne Laser	1,419.9	0.0234	0.4231	0.0099
	S			M		Software and System Engineering, Modelling and Simulation	Laser range-finder/designator	nose-mounted turret, which will house a 1.5 m telescope intended to focus laser energy onto the target and collect return signals and image data	Sensor Systems	ABL Airborne Laser	1,419.9	0.0234	0.4231	0.0099
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	PNVS (pilot night vision sensor): FLIR sensor (looking forward infrared)	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	FIREsight systems (Far Infrared)	Sensor Systems	AH-64D Apache	2,666.5	0.0426	0.2564	0.0109
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	FLIR (Forward-Looking Infra-Red) system: TRAM system acquire target on radar screen	Sensor Systems	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	Brilliant Anti-Armor Technology (BAT) : capable to seek and attack armoured targets by using high-precision passive sensors. target search by acoustic probes on the wingtips and infra-red sensors in the nose	Sensor Systems	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029

	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	an imaging dual-colour infra-red and millimetric wave radar seeker head	Sensor Systems	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	advanced photonics masts (AN/BVS-1): fitted with LLTV, IR and a laser range-finder	Sensor Systems	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	infra-red Thermal Imaging System (TIS) has been developed by the Raytheon Systems Company and produces an image by sensing the small difference in heat radiated by the objects in view. The detected energy is converted into electrical signals which are dis	Sensor Systems	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	CITV second-generation FLIR, GPS second-generation FLIR	Sensor Systems	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	externally side-mounted IR sensor, which is reported to be highly resistant to countermeasures, detects the target, works out the aim-point and triggers the warhead	Sensor Systems	[illegible]	[illegible]	0.0052	0.4359	0.0023
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	Infra-Red Search and Track System (IRSTS): Full 360° coverage is provided for surveillance, initial detection and tracking of TBMs during boost phase.	Sensor Systems	ABL Airborne Laser	1,450.1	0.0234	0.4231	0.0099
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	BMC4I segment provides surveillance, communication, planning, and the central command and control of the ABL weapon system	Flight control and Management System	ABL Airborne Laser	1,450.1	0.0234	0.4231	0.0099
	S			M		Software and System Engineering, Modelling and Simulation	Infrared sensor	Ground based Interceptor(GBIs): includes IR/Vis Seeker, IMU(inertial measurement unit), Integrated Communications, Antenna	Sensor Systems	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925

	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	Radar Detection System:Sensitive surveillance receivers in the fintip pod for long-range detection of radars	Sensor Systems	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	Norden AN/APQ-148 or AN/APQ-156 simultaneous multimode nav/attack radar	Sensor Systems	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	Litton AN/ALR-67 radar warning receiver: provides simultaneous ground mapping; identification, tracking, and range-finding of fixed or moving targets; and terrain-clearance or terrain-following manoeuvres	Sensor Systems	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	multimode radar, providing capability to detect, identify and attack a wide range of targets (as well as view the terrain) under adverse weather conditions, and with improved accuracy, using either conventional or laser-guided weapons	Sensor Systems	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	AN/APS-145 advanced radar processing system (ARPS)	Sensor Systems	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	digital air-to-air and air-to-ground radar	Sensor Systems	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	258 AESA radars (current)	Sensor Systems	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543
	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	Raytheon AN/APG-79 active electronically scanned array (AESA) radar (under development)	Sensor Systems	F/A-18E/F Super Hornet	9,446.1	0.1512	0.3590	0.0543

	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	Air search/fire control: RCA SPY-1D phased arrays: 3D: E/F-band	Sensor Systems	[illegible]	[illegible]	0.1528	0.8846	0.1352
	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	AN/SLX-1 MSTRAP(Multisensor torpedo recognition and alertment processor) with easy-to-read display: provides info, signal processing, and controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions.	Sensor Systems	[illegible]	[illegible]	0.1528	0.8846	0.1352
	S			M		Software and System Engineering, Modelling and Simulation	Radar, phased-array beamformer	Upgraded Early Warning Radar (UEWR): phased-array surveillance radars used to detect and track ballistic missiles targeted at the United States. Software upgrades to these existing early warning radars would provide the capability to support NMD surveilla	Sensor Systems	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
	S	I				Software and System Engineering, Info Management	data acquistion unit	Signals from the photonic and advanced ASTECS ESM (the AN/BLQ-10) sensors will be relayed to the Combat Control System Mk 2 and AN/BSY-2 command system via a fibre optic link and presented on flat panel displays	Sensor Systems	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S	I				Software and System Engineering, Info Management	data acquistion unit	TILL(Tracking ILluminator Laser) is the heart of the beam control/fire control system, projecting rapid, powerful pulses of light on a small section of a boosting target missile. The light will be reflected back to an extremely sensitive camera. The refl	Sensor Systems	[illegible]	[illegible]	0.0234	0.4231	0.0099
	S	I				Software and System Engineering, Info Management	data acquistion unit	Active Ranger System (ARS) house the Active Laser Ranger (ALR). The ALR consists of a modified LANTIRN 2000 system (see separate entry), with a high-power CO2 laser. The ALR will receive vector information from the Infra-Red Search and Track (IRST) system	Sensor Systems	[illegible]	[illegible]	0.0234	0.4231	0.0099
	S	I				Software and System Engineering, Info Management	data acquistion unit	nose-mounted turret, which will house a 1.5 m telescope intended to focus laser energy onto the target and collect return signals and image data	Sensor Systems	[illegible]	[illegible]	0.0234	0.4231	0.0099

	S	I				Software and System Engineering, Info Management	data acquistion unit	Upgraded Early Warning Radar (UEWR): phased-array surveillance radars used to detect and track ballistic missiles targeted at the United States. Software upgrades to these existing early warning radars would provide the capability to support NMD surveilla	Sensor Systems	National Missile Defense (NMD)	20.959.4	0.3355	0.8718	0.2925
	S	I				Software and System Engineering, Info Management	data acquistion unit	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20.959.4	0.3355	0.8718	0.2925
	S	I	V			Software and System Engineering, Info Management, Visualization and Imaging	target locator	ESM system (Passive Identification/Direction-finding Equipment or PI/DE) for passive identification and direction-finding of potential targets	Flight control and Management System	TOMAHAWK	481.9	0.0077	0.8846	0.0068
	S	I	V			Software and System Engineering, Info Management, Visualization and Imaging	target locator	Infra-Red Search and Track System (IRSTS): Full 360° coverage is provided for surveillance, initial detection and tracking of TBMs during boost phase.	Sensor Systems	ABL Airborne Laser	1.459.9	0.0234	0.4231	0.0099
	S	I	V			Software and System Engineering, Info Management, Visualization and Imaging	target locator	BMC4I segment provides surveillance, communication, planning, and the central command and control of the ABL weapon system	Flight control and Management System	ABL Airborne Laser	1.459.9	0.0234	0.4231	0.0099
	S	I	V			Software and System Engineering, Info Management, Visualization and Imaging	target locator	X-band/ Ground based radar (XBR): high frequency and advanced radar signal processing technology to improve target resolution, which permits the radar to more accurately discriminate between closely-spaced objects, perform tracking, discrimination, and ki	Sensor Systems	National Missile Defense (NMD)	20.959.4	0.3355	0.8718	0.2925
	S	I	V			Software and System Engineering, Info Management, Visualization and Imaging	target locator	BMC2 (Battle Management, Command and Control) unit: provide extensive decision support systems, battle management system, battle management display, and situation awareness information, process the information and communicate target assignments to interce	Flight control and Management System	National Missile Defense (NMD)	20.959.4	0.3355	0.8718	0.2925

	S	I		M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	central computer processes the signals for display and recording	Flight Control and Management system	EA-6B Prowler(based on A-6E Intruder)	800.4	0.0128	0.2436	0.0031
	S	I		M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	Lidar Pilot Alert System(PAS): Signal analysis is by a DY4 Systems Inc processor	Flight Control and Management system	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
	S	I		M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	perform the data processing and display functions for tens of thousands of targets and C^3I operation	Flight Control and Management system	E-8C Joint Stars	1,237.6	0.0198	0.6923	0.0137
	S	I		M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	AN/APS-145 advanced radar processing system (ARPS)	Sensor Systems	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
	S	I		M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	AN/APS-145 advanced radar processing system (ARPS): improved jamming resistance and sharper	Sensor Systems	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
	S	I		M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	processor use video information in a correlation mode, supplies final guidance corrections in the terminal phase of the cruise missile's flight to its target	Sensor Systems	TOMAHAWK	481.9	0.0077	0.8846	0.0068
	S	I		M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	Digital Scene Matching Area Correlator (DSMAC)	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068

	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	central computer processes the signals for display and recording	Flight Control and Management system	[illegible]	[illegible]	0.0128	0.2436	0.0031
	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	Lidar Pilot Alert System(PAS): Signal analysis is by a DY4 Systems Inc processor	Flight Control and Management system	[illegible]	[illegible]	0.0110	0.5256	0.0058
	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	perform the data processing and display functions for tens of thousands of targets and C3 operation	Flight Control and Management system	[illegible]	[illegible]	0.0198	0.6923	0.0137
	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	AN/APS-145 advanced radar processing system (ARPS)	Sensor Systems	[illegible]	[illegible]	0.0159	0.4231	0.0067
	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	AN/APS-145 advanced radar processing system (ARPS) improved jamming resistance and sharper	Sensor Systems	[illegible]	[illegible]	0.0159	0.4231	0.0067
	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	processe live video information in a correlation mode, suppies final guidance corrections in the terminal phase of the cruise missile's flight to its target	Sensor Systems	[illegible]	[illegible]	0.0077	0.8846	0.0068
	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	Digital Scene Matching Area Correlator (DSMAC)	Navigation	[illegible]	[illegible]	0.0077	0.8846	0.0068

	S	I			M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	Raytheon digital 3-D AN/MPQ-64 Ground-Based Sensor (Sentinel) search and track radar with built-in IFF system	Sensor Systems	AMRAAM Advanced Medium Range Air-to-air Missile	589.1	0.0094	0.3974	0.0037
	S	I			M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	AN/SLX-1 MSTRAP(Multisensor torpedo recognition and alertment processor) with easy-to-read display: provides info, signal processing, and controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions,	Sensor Systems	DDG-51 AEGIS Destroyer	9,544.6	0.1528	0.8846	0.1352
	S	I			M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	AN/SQR-19 TACTAS sonar, passive towed array sonar system	Sensor Systems	DDG-51 AEGIS Destroyer	9,544.6	0.1528	0.8846	0.1352
	S	I			M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	Signals from the photonic and advanced ASTECS ESM (the AN/BLQ-10) sensors will be relayed to the Combat Control System Mk 2 and AN/BSY-2 command system via a fibre optic link and presented on flat panel displays	Sensor Systems			0.1104	0.7051	0.0778
	S	I			M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	Signals from the photonic and advanced ASTECS ESM (the AN/BLQ-10) sensors will be relayed to the Combat Control System Mk 2 and AN/BSY-2 command system via a fibre optic link and presented on flat panel displays	Sensor Systems	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S	I			M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	CCSM(Command and Control System Module): include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, farbic optics network, tactic	Flight control and Management System	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S	I			M		Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	Infra-red Thermal Imaging System (TIS) has been developed by the Raytheon Systems Company and produces an image by sensing the small difference in heat radiated by the objects in view. The detected energy is converted into electrical signals which are dis	Sensor Systems	M1A2 Abrams Tank Upgrade	1,372.7	0.0220	0.1923	0.0042

	S	I		M	Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	signal can be processed and apply anti-jam protection	communication system	DSCS (Defense Satellite Communications System)	298.4	0.0048	0.6410	0.0031
	S	I		M	Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	GPS receivers in multiple configurations: capable of processing signals from multiple satellites simultaneously, expediting initial acquisition times	Navigation	NAVSTAR Global Positioning System	1,461.4	0.0234	0.4359	0.0102
	S	I		M	Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	X-band/ Ground based radar (XBR): high frequency and advanced radar signal processing technology to improve target resolution, which permits the radar to more accurately discriminate between closely-spaced objects, perform tracking, discrimination, and ki	Sensor Systems	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
	S	I		M	Software and System Engineering, Info Management, Modelling and Simulation	Signal Processing	Upgraded Early Warning Radar (UEWR): phased-array surveillance radars used to detect and track ballistic missiles targeted at the United States. Software upgrades to these existing early warning radars would provide the capability to support NMD surveilla	Sensor Systems	National Missile Defense (NMD)	20,959.4	0.3355	0.8718	0.2925
	S				Software and System Engineering	Synthetic Aperture	synthetic aperture mode on radar to establish GPS positional error of target for accurate high-level bombing	Sensor Systems	B-2A Spirit (Stealth Bomber)	687.6	0.0110	0.5256	0.0058
	S				Software and System Engineering	Synthetic Aperture	Bow spherical active/passive array; wide aperture flank passive arrays; high-frequency active keel and fin arrays; TB 16 and TB 29 towed arrays.	Sensor Systems	[illegible]	[illegible]	0.1104	0.7051	0.0778
	S			M	Software and System Engineering, Modelling and Simulation	Adaptive Canceller	AN/APS-145 advanced radar processing system (ARPS): improved jamming resistance	Sensor Systems	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067
	S				Software and System Engineering	Adaptive Beamformer	total radiation aperture control antenna (TRAC-A) to reduce sidelobes to offest jamming	Sensor Systems	E-2C Hawkeye	995.2	0.0159	0.4231	0.0067

	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	signal can be processed and apply anti-jam protection	communication system	[illegible]	[illegible]	0.0048	0.6410	0.0031
	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	GPS receivers in multiple configurations, capable of processing signals from multiple satellites simultaneously, expediting initial acquisition times	Navigation	*NAVSTAR Global Positioning System	1,461.4	0.0234	0.4359	0.0102
	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	X-band, Ground based radar (XBR): high frequency and advanced radar signal processing technology to improve target resolution, which permits the radar to more accurately discriminate between closely spaced objects, perform tracking discrimination, and w	Sensor Systems	[illegible]	[illegible]	0.3355	0.6718	0.2925
	S	I		M	Software and System Engineering, Info Management, Modeling and Simulation	Signal Processing	Upgraded Early Warning Radar (UEWR): phased-array surveillance radars used to detect and track ballistic missiles targeted at the United States. Software upgrades to these existing early warning radars would provide the capability to support NMD surveilla	Sensor Systems	[illegible]	[illegible]	0.3355	0.6718	0.2925
	S				Software and System Engineering	Synthetic Aperture	synthetic aperture mode on radar to establish GPS positional error of target for accurate high-level bombing	Sensor Systems	[illegible]	[illegible]	0.0110	0.5256	0.0058
	S				Software and System Engineering	Synthetic Aperture	Bow spherical active/passive array, wide aperture flank passive arrays, high frequency active keel and fin arrays, TB 16 and TB 29 towed arrays.	Sensor Systems			0.1104	0.7051	0.0778
	S			M	Software and System Engineering, Modeling and Simulation	Adaptive Cancelers	AN/APS-145 advanced radar processing system (ARPS): improved jamming resistance	Sensor Systems	[illegible]	[illegible]	0.0159	0.4231	0.0067
	S				Software and System Engineering	Adaptive Beamformer	total radiation aperture control antenna (TRAC A) to reduce sidelobes to offset jamming	Sensor Systems	[illegible]	[illegible]	0.0159	0.4231	0.0067

	S			M		Software and System Engineering, Modelling and Simulation	Acoustics Sensor	Brilliant Anti-Armor Technology (BAT) : capable to seek and attack armoured targets by using high-precision passive sensors. target search by acoustic probes on the wingtips and infra-red sensors in the nose	Sensor Systems	ATACMS (Army Tactical Missile System)	736.6	0.0118	0.2436	0.0029
	S			M		Software and System Engineering, Modelling and Simulation	Acoustics Sensor	Mk 116 ASWCS directly interfaces with shipboard acoustic sensors (typically AN/SQS-53, AN/SQR-19 and AN/SQQ-28), radar, ESM(entry monitor system), and receives offboard sensor data via datalink.	Sensor Systems	DDG-5* AEGIS Destroyer	9,544.6	0.1528	0.8846	0.1352
	S			M		Software and System Engineering, Modelling and Simulation	Array Antenna	GPS receiver with new five-element array antenna which, together with the DSMAC, is claimed to provide a 250 per cent improvement in CEP	Navigation	TOMAHAWK	481.9	0.0077	0.8846	0.0068
	S			M		Software and System Engineering, Modelling and Simulation	Array Antenna	satellite transponder(TRW systems) consisted of a multichannel repeater with cross-linked channels, a receive and transmit Earth Coverage (EC) antenna, a steerable Narrow Coverage (NC) antenna and a steerable Area Coverage (AC) antenna	Sensor Systems	DSCS (Defense Satellite Communications System)	298.4	0.0048	0.6410	0.0031
	S			M		Software and System Engineering, Modelling and Simulation	Array Antenna	NAVSTAR antenna consists of a pressure-tight broadband antenna system containing a head amplifier, together with an inboard control unit	Navigation	NAVSTAR Global Positioning System	1,461.4	0.0234	0.4359	0.0102
	S			M		Software and System Engineering, Modelling and Simulation	Sonar System	Gould/Raytheon/GE SQQ-89(V)6; combines SQS-53C, bow-mounted; active search and attack with SQR-19B passive towed array (TACTAS) low frequency	Sensor Systems	DDG-51* AEGIS Destroyer	9,544.6	0.1528	0.8846	0.1352
	S			M		Software and System Engineering, Modelling and Simulation	Sonar System	AN/SLX-1 MSTRAP(Multisensor torpedo recognition and alertment processor) with easy-to-read display: provides info, signal processing, and controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions.	Sensor Systems	DDG-51* AEGIS Destroyer	9,544.6	0.1528	0.8846	0.1352

	S			M		Software and System Engineering, Modelling and Simulation	Sonar System	Mk 116 ASWCS directly interfaces with shipboard acoustic sensors (typically AN/SQS-53, AN/SQR-19 and AN/SQQ-28), radar, ESM(entry monitor system), and receives offboard sensor data via datalink.	Sensor Systems	DDG-51 AEGIS Destroyer	9,544.8	0.1528	0.8846	0.1352
	S			M		Software and System Engineering, Modelling and Simulation	Sonar System	AN/SQR-19 TACTAS sonar, passive towed array sonar system	Sensor Systems	DDG-51 AEGIS Destroyer	9,544.8	0.1528	0.8846	0.1352
	S			M		Software and System Engineering, Modelling and Simulation	Sonar System	Bow spherical active/passive array; wide aperture flank passive arrays; high-frequency active keel and fin arrays; TB 16 and TB 29 towed arrays.	Sensor Systems	SQS-56 Virginia Class Submarine	4,419.6	0.1104	0.7051	0.0778
					IT	IT in Communication	Anti-jamming mechanism	signal can be processed and apply anti-jam protection	communication system	DSCS (Defense Satellite Communications System)	298.4	0.0048	0.6410	0.0031
					IT	IT in Communication	Anti-jamming mechanism	GPS receivers have an advanced anti-jamming and anti-spoofing capability	Navigation	NAVSTAR Global Positioning System	1,461.4	0.0234	0.4359	0.0102

	S			M	Software and System Engineering, Modelling and Simulation	Acoustic Sensor	Bi-static Anti-Armor Technology (BAT) - capable to sense and attack armoured targets by using high-precision pressure sensors, beam-switch by acoustic probes on the aeroplane and ultra-fast sensors in the nose	Sensor Systems			0.0158	0.2436	0.0023
	S			M	Software and System Engineering, Modelling and Simulation	Acoustic Sensor	Mk 116 ASWCS directly interfaces with shipboard acoustic sensors (typically AN/SQS-53, AN/SQR-19 and AN/SQQ-28) radar, ESM/early-warning system), and receives offboard sensor data via datalink	Sensor Systems			0.1628	0.0846	0.1352
	S			M	Software and System Engineering, Modelling and Simulation	Array Antennas	GPS receiver with new five-element array antenna which, together with the DSMAC, is claimed to provide a 250 per cent improvement in CEP	Navigation			0.0017	0.0846	0.0009
	S			M	Software and System Engineering, Modelling and Simulation	Array Antennas	Satellite Communication (SATCOM) systems consisted of a multichannel transponder with a transmit channel, a receive channel, Earth Coverage (EC) antenna, a Spot beam Coverage (SC) antenna, a Global Area Coverage (GC) antenna	Sensor Systems			0.0840	0.6430	0.0011
	S			M	Software and System Engineering, Modelling and Simulation	Array Antennas	NAVSTAR antenna consists of a pressure tight, beryllium reflector system containing a feed network. Together with an [illegible] unit	Navigation			0.0234	0.4260	0.0017
	S			M	Software and System Engineering, Modelling and Simulation	Array Antennas	Sonar Platform GE SQQ 89(V)6, combines SQS-53C low-mounted active search and attack with SQR-19B passive towed array (TACTAS) for frequency	Sensor Systems			0.1628	0.0846	0.1352
	S			M	Software and System Engineering, Modelling and Simulation	Acoustic Sensor	AN/SLR-7 SPECTRAVM(Multifunctional towed) - navigation and sediment penetrator with proxy for local oceanic properties, SIL signal processing, and sonobuoy necessary for detect, classify and localize threat torpedoes. It also allows command and control functions	Sensor Systems			0.1628	0.0846	0.1352

	S			M	Software and System Engineering, Modeling and Simulation	Sensor Systems	Be the network-centricity interfaces with supported networks, ensure physical ANSI/IEEE 51, ANSI/IEEE 1451.2 and ANSI/IEEE 1451.4 also LSMeshNet reports synthetic and receives offboard sensor data via network.	Sensor Systems			0.1525	0.0646	0.0350
	S			M	Software and System Engineering, Modeling and Simulation	Sensor Systems	ANSI/IEEE 1451 FACT AS sonar, passive towed array sonar system	Sensor Systems			0.1525	0.0646	0.1352
	S			M	Software and System Engineering, Modeling and Simulation	Sensor Systems	flow sensors or synchronous array, wide aperture, bank passive array, high frequency active sonar and frequency, TB-76 and TB-29 towed arrays	Sensor Systems			0.1394	0.2955	0.0770
				H	IT in Communications	Sensor Systems	signal can be processed and optical and protection	communication system			0.2048	0.0419	0.0511
				H	IT in Communications	Sensor Systems	GPS, or inertial, radar, or acoustic and sonobuoy and anti-sounding capability	Navigation	Navigation	Navigation	0.1024	0.1024	0.1052